Missouri State Hazard Mitigation Plan

July 2013

Jeremiah W. (Jay) Nixon
Governor

Jerry Lee
Director of Public Safety

STATE OF MISSOURI
EMERGENCY MANAGEMENT AGENCY
DEPARTMENT OF PUBLIC SAFETY
PO Box 116, Jefferson City, Missouri 65102
Phone: 573/526-9100 Fax: 573/634-7966
E-mail: mosema@sema.dps.mo.gov

Timothy A. Diemler
Acting Director

June 18, 2013

MEMORANDUM OF APPROVAL & ADOPTION

TO: **All Missouri State Hazard Mitigation Plan Holders**

From: **Timothy A. Diemler, Acting Director of SEMA**

This newly revised Missouri State Hazard Mitigation Plan is hereby approved and adopted. It is the result of the collective suggestions, participation, support and hard work contributed over the years by the departments, agencies, sub-agencies and special entities established by the State of Missouri, Seismic Safety Commission, the Structural Assessment and Visual Evaluation (SAVE) Coalition, the Association of State Floodplain Managers (ASFPM) and its Missouri chapter, the United States Army Corps of Engineers, the Federal Emergency Management Agency (FEMA) and various other Federal agencies, the nineteen (19) Missouri Regional Planning Commissions and/or Councils of Government (RPC's) of the Missouri Association of Councils of Governments (MACOG), Rural Electric Cooperatives (REC's) throughout the State of Missouri, multiple professional organizations, volunteer agencies, special consortiums, concerned citizens and SEMA staff.

The purpose of the Missouri State Hazard Mitigation Plan is to provide guidance, direction and prioritization for mitigation activities and projects within the state, including those financed with Federal funding provided by FEMA. The plan contains an analysis of Missouri's hazards, risks and vulnerabilities, describes the manner in which mitigation is planned, programmed and carried out, and establishes SEMA's hazard mitigation goals, objectives and recommended actions and initiatives that will reduce injuries, damages and loss of life caused by disasters. SEMA encourages all Missouri departments, agencies, sub-agencies, offices and special entities to incorporate the principals, information and ideas included in this plan into their own plans for programs and activities.

Sincerely,

Timothy A Diemler
Timothy A. Diemler
Acting Director

TAD:rcb

CHAPTER 1 Table of Contents

THIS PAGE INTENTIONALLY LEFT BLANK

Across the United States, natural, manmade, and other disasters have led to increasing numbers of deaths, injuries, property damages, and disruptions of business and government services. This can take an immense toll on people, businesses and government, especially in these challenging economic times. The time, money and effort to respond to and recover from disasters divert public resources and attention from other important programs. As of June 2013, Missouri has had a total of 53 federal declaration and five emergency federal declaration events since 1957 and ranks 10th in the U.S. for the number of federal declarations during this time period. Missouri recognizes the consequences of disasters and the need to reduce the impacts of natural, manmade, and other disasters.

Hazard mitigation is defined by the Federal Emergency Management Agency (FEMA) as any action taken to eliminate or reduce the long-term risk to human life and property from hazards and their effects. This is crucial to the residents, businesses, and governments of Missouri. Hazard Mitigation is the only phase of emergency management specifically dedicated to breaking the cycle of damage, reconstruction, and repeated damage.

People and property in Missouri are at risk from a variety of hazards. Among other hazards, Missouri is at risk to tornadoes, floods, drought, earthquakes, severe winter weather, and wildfires that have the potential for causing widespread loss of life and damage to property, infrastructure, and the environment. Missouri recognizes the potential consequences of disaster events. The need to reduce the impacts through proper planning and preventive measures is of great importance to the State and its residents.

This Missouri State Hazard Mitigation Plan is an important planning component of state-level programs for management of disasters and their impacts. It takes into account years of mitigation experience and a variety of mitigation initiatives in Missouri and other state partners. It has also taken advantage of the collective mitigation knowledge of many state, federal, and local officials as well as multiple stakeholders throughout the private sector. As such, it should significantly contribute to the mitigation of future Missouri disasters.

It also establishes the means the State will use to identify cost-effective mitigation measures, to reduce and/or eliminate the long-term risk to human life and property from all hazards (natural, manmade, and other). The priorities include local community mitigation planning, acquisition of floodprone properties, relocation/retrofitting of floodprone properties, floodplain management, tornado safe rooms, flood and earthquake structural projects, and technical assistance. Both short-term and long-term hazard mitigation measures are identified and prioritized to help all state and local agencies allocate appropriate resources in a responsible manner that will provide for the health, safety, and general welfare of all people in Missouri.

CHAPTER 1 Introduction

This plan will continue to provide a general blueprint for hazard mitigation activities in Missouri and is structured to serve as the basis for specific hazard mitigation efforts for multiple hazards. It is done so in a manner that meets federal requirements for mitigation planning and that complies with collaboratively developed national standards for emergency management. (As such, it is approved by FEMA and accredited by the Emergency Management Accreditation Program (EMAP).) Updates may be required to address specific issues arising from a given hazard event or based on changes in federal or state laws and regulations.

Organization

Technical Note*: This document is a User Interfaced, Web Based Interactive Document. It has been formatted with active embedded hyperlinks throughout. There are several different types of hyperlinks.*

Hyperlinks within the document: Some of the hyperlinks will direct the user to specific sections of the plan where referenced information may be found. These links are identified by a blue color format.

Hyperlinks to SEMA website: Some of the hyperlinks will direct the user to a SEMA website to access reference documents and resource data. Some of these documents are password protected and the user will be directed to obtain credentials from SEMA to gain access. These links are identified by a red color format.

Hyperlinks to external websites: These hyperlinks will direct the user to a third party website where additional information can be found. As with all hyperlinks to external sites, if the site administrator makes changes to the URL, these can expire or become non-functional. These links are identified by a green color format.

The following table provides a list of the hyperlinks throughout this document that will direct the user to a SEMA website to access supplemental documentation and research materials that were compiled in development of the risk assessment.

No.	Description	Hyperlink	Chapter (s)	Password Required Y/N
1	EMAP Standard, September 2007	http://floodplain.sema.dps.mo.gov/MitPlan/docs.aspx?link=EMAPstd	3,7	No
2	Documentation of 2010 Mitigation Plan Update Planning Process	http://floodplain.sema.dps.mo.gov/MitPlan/docs.aspx?link=Process	2	Yes

No.	Description	Hyperlink	Chapter (s)	Password Required Y/N
3	Approved Local Plans-PDF's of the approved local plans are provided at this link.	http://floodplain.sema.dps.mo.gov/MitPlan/docs.aspx?link=Approved_Local_Plans	2,3, 5	No
4	Rules and Regulations of the Missouri Dam and Reservoir Safety Council, 1994	http://floodplain.sema.dps.mo.gov/MitPlan/docs.aspx?link=modamreg94	3	No
5	October 2009 Missouri Dam Inventory	http://floodplain.sema.dps.mo.gov/MitPlan/docs.aspx?link=modaminventory	3	Yes
6	Details of Paid Crop Insurance Claims by Hazard from USDA's Risk Management Agency, 2004-2008	http://floodplain.sema.dps.mo.gov/MitPlan/docs.aspx?link=cropclaims	3	No
7	Missouri Drought Plan, 2002	http://floodplain.sema.dps.mo.gov/MitPlan/docs.aspx?link=modroughtplan	3	No
8	Impacts of Earthquakes on the Central USA; MAE Center Report No. 08-02, September 2008	http://floodplain.sema.dps.mo.gov/MitPlan/docs.aspx?link=MAErpt	3	No
9	Census Data compiled from the U.S. Census Bureau	http://floodplain.sema.dps.mo.gov/MitPlan/docs.aspx?link=censusdata	3	No
10	Missouri DNR Dam and Reservoir Safety Program, Emergency Action Plan Template, 2010	http://floodplain.sema.dps.mo.gov/MitPlan/docs.aspx?link=EAPtemplate	3	No
11	Vulnerability Analysis: Failure of State-owned Dams	http://floodplain.sema.dps.mo.gov/MitPlan/docs.aspx?link=damvulnerability	3	No
12	State-owned Facilities Potentially Impacted by Failure of State-owned Dams	http://floodplain.sema.dps.mo.gov/MitPlan/docs.aspx?link=Sofacilitiesdamanalysis	3	Yes

No.	Description	Hyperlink	Chapter (s)	Password Required Y/N
13	Earthquake Vulnerability Analysis for State-owned Facilities	http://floodplain.sema.dps.mo.gov/MitPlan/docs.aspx?link=SOfacilitiesEQanalysis	3	Yes
14	Earthquake vulnerability Analysis for State-owned Bridges	http://floodplain.sema.dps.mo.gov/MitPlan/docs.aspx?link=MoDOTbridgeEQanalysis	3	Yes
15	Flood Vulnerability Analysis for State-owned Facilities	http://floodplain.sema.dps.mo.gov/MitPlan/docs.aspx?link=Sofacilitiesfloodanalysis	3	Yes
16	Interactive Map of Missouri Public and Independent Colleges and Universities	http://floodplain.sema.dps.mo.gov/MitPlan/docs.aspx?link=collegesanduniversities	3	No
17	Article Referencing Impact of Disasters on the Missouri Department of Conservation	http://floodplain.sema.dps.mo.gov/MitPlan/docs.aspx?link=MDCarticle	3	No
18	Summary Spreadsheet of grants with Missouri CDBG 2008 Disaster Supplemental funding and Regular CDBG funding.	http://floodplain.sema.dps.mo.gov/MitPlan/docs.aspx?link=CDBG_grants	4	No
19	List of Past Hazard Mitigation Assistance Projects	http://floodplain.sema.dps.mo.gov/MitPlan/docs.aspx?link=Past_Mitigation_Projects	4,7	No
20	State Mitigation Activities Matrix--Demonstrating Alignment with EMAP Mitigation Elements	http://floodplain.sema.dps.mo.gov/MitPlan/docs.aspx?link=EMAP_Matrix	4	No
21	Funding Assistance is a comprehensive list of federal funding and assistance grants.	http://floodplain.sema.dps.mo.gov/MitPlan/docs.aspx?link=FundingAssistnace	4	No
22	Methodology for Determining Vulnerability to Dam and Levee Failure	http://floodplain.sema.dps.mo.gov/MitPlan/docs.aspx?link=HAZUS_Inst_Dam_Levee	5	No

No.	Description	Hyperlink	Chapter (s)	Password Required Y/N
23	County PDF Floodplain Maps	http://floodplain.sema.dps.mo.gov/MitPlan/docs.aspx?link=County_PDF_Floodplain_Maps	5	No
24	FEMA Hazard Mitigation Assistance Guidance, June 1, 2009	http://floodplain.sema.dps.mo.gov/MitPlan/docs.aspx?link=HMAGuidance	6	No
25	SEMA Floodplain Management Courses 2007-2009	http://floodplain.sema.dps.mo.gov/MitPlan/docs.aspx?link=Floodplain_Management_Courses	7	No
26	Loss Avoidance Study: Eastern Missouri, Building Acquisition, May 2009	http://floodplain.sema.dps.mo.gov/MitPlan/docs.aspx?link=Loss_Avoidance_Study	7	No
27	Stemming the Tide of Flood Losses: Stories of Success from the History of Missouri's Flood Mitigation Program	http://floodplain.sema.dps.mo.gov/MitPlan/docs.aspx?link=Stemming_the_Tide	7	No
28	Success Stories	http://floodplain.sema.dps.mo.gov/MitPlan/docs.aspx?link=Success_Stories	7	No
29	Missouri Flood Mitigation Project	http://floodplain.sema.dps.mo.gov/MitPlan/docs.aspx?link=Missouri_Flood_Mitigation_Project	7	No

CHAPTER 1 Introduction

This plan is organized around FEMA's mitigation planning process and is divided into seven chapters, briefly summarized below:

- **Chapter 1 Prerequisite (link)** includes the state's adoption of the plan and assurances that the state will comply with all applicable federal statutes and regulations.
- **Chapter 2 Planning Process (link)** explains the planning process, including how it was prepared, who was involved, and how it was integrated with other related planning efforts.
- **Chapter 3 Risk Assessment (link)** features the risk assessment, which identifies the type and location of hazards that can affect Missouri, analyzes the state's vulnerability to the hazards identified, and serves as the factual basis for the mitigation strategy.
- **Chapter 4 Comprehensive State Hazard Mitigation Program (link)** provides the state's mitigation blueprint. Specifically, it includes goals and objectives, state and local capabilities, mitigation activities, and funding sources.
- **Chapter 5 Coordination of Local Mitigation Planning (link)** describes the state's role in funding, developing, coordinating, and approving local mitigation plans, and how the state prioritizes funding for local mitigation plans and projects.
- **Chapter 6 Plan Maintenance (link)** presents the method the State Hazard Mitigation Planning Team (SHMPT) uses to monitor, evaluate, and update the plan. It also introduces how the team monitors project implementation and closeouts and reviews progress on achieving goals.
- **Chapter 7 Enhanced Plan (link)** is the "enhanced" portion of the plan and documents Missouri's project implementation capability and commitment to a comprehensive mitigation program.

THIS PAGE INTENTIONALLY LEFT BLANK

CHAPTER 1 Prerequisites

Hazard mitigation has become an increasingly important component of disaster recovery since 1988 when the Disaster Relief Act of 1974, Public Law 93-288, was amended by Public Law 100-707, the Robert T. Stafford Disaster Relief and Emergency Assistance Act. Greater emphasis was placed on hazard mitigation and pre-disaster mitigation (Section 203) with the enactment of another amendment, the Disaster Mitigation Act of 2000. This Missouri State Hazard Mitigation Plan is a direct result of the latter amendment to the Stafford Act.

The Disaster Mitigation Act (DMA) of 2000 enacted the following provisions relative to mitigation planning:

Standard State Mitigation Plans (201.4 of the Rule): To receive federal mitigation funds, states must develop and submit for approval to FEMA a Standard Hazard Mitigation Plan that includes details of the State's natural hazards risks, vulnerabilities, and mitigation goals, objectives, and priorities. States with an approved Standard Hazard Mitigation Plan are eligible for Hazard Mitigation Grant Program (HMGP) funding based on 15 percent for disaster assistance not more than $2 billion, 10 percent for disaster assistance of more than $2 billion and not more than $10 billion, and 7.5 percent for disaster assistance more than $10 billion and not more than $35.3 billion of the total estimated eligible Stafford Act disaster assistance as a result of a presidential major disaster declaration.

Enhanced State Mitigation Plans (201.5 of the Rule): States that have an approved Enhanced State Mitigation Plan at the time of a disaster declaration will qualify to receive HMGP funds based on up to 20 percent of the total estimated eligible Stafford Act disaster assistance. This document is the scheduled 2013 update to Missouri's standard and enhanced state hazard mitigation plan, which was initially approved by FEMA in 2004 and previously updated in 2007 and 2010.

Section 404 (Hazard Mitigation Grant Program (HMGP)) allows the federal government to contribute up to 75 percent of the cost of cost-effective hazard mitigation measures that substantially reduce the risk of future damage, hardship, loss, or suffering in any area affected by a major disaster. Such mitigation measures shall be identified following the evaluation of natural hazards under Section 322 of the Disaster Mitigation Act. Section 404 funds may be used for a variety of eligible projects that may or may not be related to the disaster and, if the State allows, in counties that were not in the declared disaster area.

In addition, to the HMGP, other funding mechanisms are available in Missouri with an approved standard state plan. These programs listed below are further described in Chapter 4 of this plan.

- FEMA Public Assistance (Categories C-G)
- Flood Mitigation Assistance Program

- Pre-Disaster Mitigation Program
- Repetitive Flood Claims Grant
- Severe Repetitive Loss Program

1.1 Plan Adoption

Requirement §201.4(c)(6):	The plan must be formally adopted by the State prior to submittal to [FEMA] for final review and approval.

The Missouri State Hazard Mitigation Plan is the result of the systematic evaluation of the nature and extent of vulnerability to the effects of all hazards (natural, manmade, and other) present in Missouri and includes the actions needed to minimize future vulnerability to those hazards. It sets forth the policies, procedures, and philosophies that will be used to establish and implement hazard mitigation activities within the State. Effective and consistent implementation of this plan is crucial to the hazard mitigation program and the State's efforts to reduce or eliminate the threat of future disasters. This plan, initially adopted May 12, 2004, incorporates all changes associated with the implementation of the federal/state hazard mitigation program, including the applicable sections of the DMA 2000 and is in compliance with the mitigation standards for accreditation outlined in the EMAP.

Overall administration of the hazard mitigation program is the responsibility of the Missouri State Emergency Management Agency (SEMA) Logistics, Resources, Mitigation and Floodplain Management Branch. This branch will review the plan annually or as needed if hazard mitigation regulations or guidelines change. The plan will be updated every three years or as required. Additionally, the plan or update will be submitted to FEMA Region VII following a presidential disaster declaration if the State's priorities change.

The 2007 update of the Missouri State Hazard Mitigation Plan was approved and adopted by the State and then submitted to FEMA Region VII on June 13, 2007. The plan was approved by FEMA Region VII on July 26, 2007. The 2010 update of the Missouri State Hazard Mitigation Plan was approved by the State and then submitted to FEMA Region VII on April 19, 2010. The plan was approved by FEMA on July 26, 2010.

The 2013 update of the Missouri State Hazard Mitigation Plan was submitted to the director of SEMA, as the authorized representative of the governor, for his approval. He approved the plan on June 10, 2013 and declared the document to be officially adopted by the State. The plan was approved by FEMA on July 29, 2013.

1.2 Compliance with Federal and State Laws and Regulations

Requirement §201.4(c)(7):	The plan must include assurances that the State will comply with all applicable Federal statutes and regulations in effect with respect to the periods for which it receives grant funding, in compliance with 44 CFR 13.11(c). The State will amend its plan whenever necessary to reflect changes in State or Federal laws and statutes as required in 44 CFR 13.11(d).

1.2.1 General Compliance Assurance Statement

This plan is prepared to comply with the requirements of the Robert T. Stafford Disaster Relief and Emergency Assistance Act of 1988 (as amended by the DMA); all pertinent presidential directives associated with the U.S. Department of Homeland Security and FEMA; all aspects of 44 CFR pertaining to hazard mitigation planning and grants pertaining to the mitigation of adverse effects of disasters (natural, manmade, and other); interim final rules and final rules pertaining to hazard mitigation planning and grants, as described above; all planning criteria issued by FEMA; and all Office of Management and Budget circulars and other federal government documents, guidelines, and rules.

The State of Missouri agrees to comply with all federal statutes and regulations in effect with respect to mitigation grants it receives, in compliance with 44 CFR 13.11 (c). As stated in Section 1.1 Plan Adoption, the plan will be updated every three years or as required and amendments will be made as necessary to address changes in federal or state statutes, regulations, and policies. Such amendments will be submitted to FEMA for approval. Additional information about how the plan will be reviewed and updated is in Section 6.1.1 Plan Maintenance Process The next update of the plan is scheduled for 2016 or as required.

SEMA intends to comply with all administrative requirements outlined in 44 CFR 13 and 206 in their entirety and to monitor all subgrant supported activities to ensure compliance with 44 CFR 13 and 206 in their entirety.

SEMA also, requires all subgrantees receiving $500,000 or more in federal assistance to have an audit conducted in accordance with the Single Audit Act under 44 CFR 14, Administration of Grants: Audits of State and Local Governments . Such reports by an independent certified public accountant will be

maintained by SEMA. All general audit requirements in 44 CFR 14 will be adhered to by SEMA as well as subgrantees receiving FEMA hazard mitigation grant awards.

1.2.2 Authorities

The Missouri State Hazard Mitigation Plan is an important component of state-level programs for management of disasters and their impacts. As such, the strategy relies on the authorities given to the state agencies and their programs herein incorporated for implementation of its strategies and assignments. Further, the plan is intended to be consistent with and supportive of the policies, plans, and implementation procedures that govern mitigation-related state agency programs. In the event of any inconsistency, state agency policies and programs supersede the provisions of the plan. The State's mitigation strategy relies upon and is intended to be consistent with the following specific state and federal authorities as well as EMAP mitigation standards:

Statutes

State

- Constitution of the State of Missouri, as amended
- Chapter 44, Emergency Management, Revised Statutes of Missouri, as amended
- Chapter 160.451-160.457, Schools—General Provisions, Earthquake Emergency Procedure, Revised Statutes of Missouri, 2003
- Chapter 256, Geology, Water Resources, and Geodetic Survey, Interstate Earthquake Emergency Compact and Geologic Hazard Assessment, Revised Statutes of Missouri, 2003
- Chapter 319, General Safety Requirements, Pipelines, Seismic Building Ordinances, Revised Statutes of Missouri, 2003

Federal*

- The National Security Act of 1947
- Public Law 84-99 (33 USC 701n) for flood emergencies
- Public Law 85-256, Price-Anderson Act
- Public Law 89-665 (16 USC 470 et seq.), National Historic Preservation Act
- Public Law 90-448, National Flood Insurance Act of 1968 (42 USC 4001 et seq.)
- Public Law 91-646, Uniform Relocation Assistance and Peal Property Acquisition Policies Act of 1970 (42 U.S.C. 4601 et seq.)
- Public Law 93-288, as amended by Public Law 100-707, The Robert T. Stafford Disaster Relief and Emergency Assistance Act (42 U.S.C. 6121 et seq.)
- Public Law 93-234, Flood Disaster Protection Act of 1973

- Public Law 95-124, as amended by Public Laws 96-472 and 99-105, Earthquake Hazards Reduction Act of 1977 (42 USC 7701 and 7704)
- Public Law 96-295, The Nuclear Regulatory Commission Appropriations Authorization Act
- Public Law 96-510, Comprehensive Environmental Response, Compensation, and Liability Act of 1980, Section 104(i),(42 USC 9604(i))
- Public Law 99-499, Superfund Amendments and Reauthorization Act of 1986
- Public Law 101-615, Hazardous Materials Transportation Uniform Safety Act
- Public Law 101-549, Clean Air Amendments of 1990
- Public Law 107-296, Homeland Security Act of 2002

*As amended where applicable

Administrative Rules

Federal

- 44 CFR Part 9, Floodplain Management and Protection of Wetlands
- 44 CFR Part 10, Environmental Considerations
- 44 CFR Part 13 (The Common Rule), Uniform Administrative Requirements for Grants and Cooperative Agreements
- 44 CFR Part 14, Audits of State and Local Governments
- 44 CFR Parts 59-76, National Flood Insurance Program and related programs
- 44 CFR Part 201, Mitigation Planning
- 44 CFR Part 206, Federal Disaster Assistance for Disasters Declared after November 23, 1988
- 49 CFR Part 24, Uniform Relocation Assistance and Real Property Acquisition for Federal and Federally Assisted Programs

Executive Orders

State

- 82-19, Provisions for the necessary and appropriate state coordination and participation with the Federal Insurance Administration under the National Flood Insurance Act of 1968
- 93-40, Establishes the Task Force on Flood Plain Management
- 94-25, Established the Disaster Recovery Partnership with human services disaster response
- 97-09, Authorizes SEMA to issue floodplain development permits for any state owned or leased development in a special flood hazard area.
- 03-23, Reaffirms the endeavors of the Disaster Recovery Partnership and ascribes to it the additional functions of a state citizen council.

- 05-20, Establishes the Missouri Homeland Security Advisory Council to review and evaluate current state and local homeland security plans
- 06-10, Creates the Citizen Corps to help coordinate volunteer and individual or family preparedness activities in any emergency situation.
- 06-41, Creates the Interdepartmental Coordination Council for Water Quality
- 09-25, Creates and establishes the Governor's Faith-Based and Community Service Partnership for Disaster Recovery.

Federal

- Executive Order 11988, Floodplain Management
- Executive Order 11990, Protection of Wetlands
- Executive Order 12656, Assignment of Emergency Preparedness Responsibilities
- Executive Order 12148, Federal Emergency Management
- Executive Order 12699, Seismic Safety of Federal and Federally Assisted or Regulated New Building Construction
- Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations
- Homeland Security Presidential Directive 5, Management of Domestic Incidents, February 28, 2003
- Homeland Security Presidential Directive 8, National Preparedness, December 17, 2003.

Other

Emergency Management Accreditation Program

- Hazard Identification and Risk Assessment Standards 5.3.1, 5.3.2, and 5.3.3
- Hazard Mitigation Standards 5.4.1, 5.4.2, and 5.4.3

This chapter documents the process used to develop this plan, including how the State coordinates with other agencies and planning efforts.

Technical Note*: This document is a User Interfaced, Web Based Interactive Document. It has been formatted with active embedded hyperlinks throughout. There are several different types of hyperlinks. Hyperlinks within the document: Some of the hyperlinks will direct the user to specific sections of the plan where referenced information may be found.* ***These links are identified by a blue color format.***

Hyperlinks to SEMA website: Some of the hyperlinks will direct the user to a SEMA website to access reference documents and resource data. Some of these documents are password protected and the user will be directed to obtain credentials from SEMA to gain access. These links are identified by a red color format.

Hyperlinks to external websites: These hyperlinks will direct the user to a third party website where additional information can be found. As with all hyperlinks to external sites, if the site administrator makes changes to the URL, these can expire or become non-functional. These links are identified by a green color format.

The chapter is divided into three parts:

2.1 Documentation of the Planning Process

Requirement §201.4(c)(1):	[The State plan must include] a description of the planning process used to develop the plan, including how it was prepared, who was involved in the process, and how other agencies participated.

The process established for this planning effort is based on the Disaster Mitigation Act of 2000 (DMA 2000) planning and update requirements and FEMA's associated guidance for state hazard mitigation plans. The primary steps in the planning process were:

1) Identify the types of hazards (natural, manmade, and other) that affect the State and develop a brief history of each;
2) Determine the present and future risk and vulnerability of Missouri residents to these hazards;
3) Assess the capabilities at the local, state, and federal levels to mitigate hazards and disasters;
4) Establish and prioritize the major hazard mitigation issues that should be addressed in the Missouri State Hazard Mitigation Plan; and
5) Identify goals, objectives, and actions for addressing these issues to reduce the State's vulnerability to present and future hazards.

2.1.1 Evolution of the State Hazard Mitigation Plan

The Missouri State Hazard Mitigation Plan was developed over several years. Initially, mitigation goals and objectives were developed separately by a number of entities. Over the years, these were incorporated into Missouri's original Section 409/hazard mitigation plan developed in 1994 and, subsequently, into the 2004 Missouri State Hazard Mitigation Plan, and the 2007 and 2010 Plan Updates.

The 2004 plan was the first Missouri Hazard Mitigation Plan written specifically to comply with the DMA 2000. This plan was the result of the combined efforts and multiyear contributions of many entities. State agencies provided input on their own ongoing mitigation initiatives and possible sources of funding for mitigation projects. A State Hazard Mitigation Planning Team (SHMPT) was formed to develop the 2004 state plan and continued for the 2007 and 2010 plan updates. This team evolved to include several federal agencies and for the this 2013 state plan update the State Risk Management Team (SRMT) . This plan is an update of the plan approved in July 2010. This plan can provide a good example for the local plan developers to help in developing local county plans.

Missouri employs a continuous improvement process to ensure that the State's mitigation planning and program efforts are effective. Missouri's planning and program successes to date are demonstrated throughout this document.

2.1.2 2013 Plan Update Process

In October 2012, Missouri initiated the planning process to update the Missouri State Hazard Mitigation Plan. The Missouri State Emergency Management Agency (SEMA) took the lead role, under the direction of the Logistics, Resources, Mitigation and Floodplain Management Branch, with the branch chief as the planning lead. For assistance in development of the plan update, SEMA contracted with Michael Baker Jr. (MBJ).

Michael Baker Jr.'s role was to:

- Assist in identifying representatives and reconvening the SRMT as defined by the DMA 2000
- Meet the DMA requirements as established by federal regulations and following FEMA's state plan update guidance
- Facilitate the entire planning process
- Identify the data requirements that SRMT participants should provide and conduct the research and documentation necessary to augment that data
- Complete labor intensive tasks including completion of Hazus flood and earthquake loss estimations, producing annualized flood damage loss maps per county in Missouri, integrating local level risk assessments, improving statewide vulnerability assessment, improving vulnerability analysis of state facilities, developing hazard mitigation assistance grant project databases for GIS tracking and display, and updating the web based flood visualization tool
- Produce the draft and final plan documents
- Coordinate with the FEMA Region VII plan reviewers

Coordination with the State Hazard Mitigation Planning Team

SEMA identified representatives from state and federal departments, the Missouri Association of Councils of Governments, Regional Planning Commissions, private non-profit associations, representatives from the nuclear power plants, and associations of public electrical providers to participate on the SRMT. The selection of representatives invited to participate on the SRMT was based on previous involvement with state mitigation planning activities or those that have a stake in reducing hazard losses in Missouri.

As seen in Table 2.1.2a below, a large number of representatives from the 2010 plan update participated in the process. M any of these representatives had been actively involved with SEMA with the 5 federal disasters between June 2009 and April 2013. In addition, SEMA participated in the Silver Jackets Program, again after the 2008 floods that was an Interagency Flood Risk Management Team that consisted of regional, state, USACE, and FEMA partners. Thus, overall visibility of emergency management and mitigation initiatives in the State increased since the 2010 plan update.

Table 2.1.2a provides the list of entities invited to attend as well as those represented at the planning meetings for the 2013 update of the State Mitigation Plan. For historical reference, those that participated in the 2010 plan update process are identified.

Table 2.1.2a Agencies Solicited and Representative Attended Planning Meetings in the 2013 Plan Update Process

Agency/Division	Participated in 2010 Plan	Solicited in 2013	Meeting 1	Meeting 2	Responded on Monkey Survey	Meeting 3
Missouri State Agencies						
State Emergency Management Agency (SEMA)	X	X	X	X	X	X
Department of Agriculture (MDA)	X	X	X			
Department of Conservation (MDC)	X	X				
Department of Corrections (MOC)	X	X	X		X	
Department of Economic Development (DED)	X	X		X		X
Department of Elementary and Secondary Education (DESE)	X	X				
Department of Health and Senior Services (DHSS)	X	X	X	X	X	
Department of Higher Education (DHE)	X	X		X	X	X
Department of Insurance, Financial Institutions, and Professional Registration (DIFP)	X	X				
Department of Labor and Industrial Relations (DOLIR)	X	X			X	
Department of Mental Health (DMH)	X	X	X	X	X	X
Department of Natural Resources (DNR), Dam Safety	X	X	X	X	X	
DNR, Division of Geology and Land Survey (DGLS)	X	X				X
DNR, Energy Center	X	X				

Agency/Division	Participated in 2010 Plan	Solicited in 2013	Meeting 1	Meeting 2	Responded on Monkey Survey	Meeting 3
DNR, Environmental Services Program	X	X				X
Department of Public Safety (DPS), Division of Fire Safety (DFS)	X	X		X	X	
DPS, State Highway Patrol (MSHP)	X	X				X
DPS, State Water Patrol (MSWP)	X					X
Public Service Commission (PSC)	X	X	X	X	X	
Department of Social Services (DSS)	X	X		X	X	X
Department of Transportation (MoDOT)	X	X	X	X		X
Division of Tourism	X	X				
Office of Administration (OA)	X	X	X	X	X	X
National Guard (MONG)	X	X		X		
National Air Guard (MOANG)	X	X		X		
Missouri Association of Council of Governments (MACOG) Stakeholders					X	
Boonslick Regional Planning Commission		X				
Bootheel Regional Planning and Economic Development Commission		X				
East-West Gateway Coordinating Council		X				
Green Hills Regional Planning Commission		X				
Harry S Truman Coordinating Council		X				
Kaysinger Basin Regional Planning Commission		X				
Lake of the Ozarks Council of Local Governments		X				
Mark Twain Regional Council of Governments		X				
Meramec Regional Planning Commission		X				
Mid-America Regional Council	X	X				X
Mid-Missouri Regional Planning Commission	X	X				X
Mo-Kan Regional Council		X				
Northeast Missouri Regional Planning Commission	X	X				X
Northwest Missouri Regional Council of Governments		X				
Ozark Foothills Regional Planning Commission		X				
Pioneer Trails Regional Planning Commission		X				
South Central Ozark Council of Governments		X				
Southeast Missouri Regional Planning and Economic Development Commission		X				
Southwest Missouri Council of Governments		X				
Federal Stakeholders						

Agency/Division	Participated in 2010 Plan	Solicited in 2013	Meeting 1	Meeting 2	Responded on Monkey Survey	Meeting 3
FEMA Region VII	X	X	X	X	X	X
National Oceanic and Atmospheric Administration National Weather Service	X	X	X		X	
U.S. Army Corps of Engineers (USACE) Kansas City	X	X		X	X	X
USACE Little Rock District		X		X	X	
USACE St Louis District	X	X	X	X	X	
USACE Memphis District		X			X	
USACE Rock Island District		X				
USACE Omaha District		X				
USACE Tulsa District					X	
U.S. Department of Agriculture (USDA), Forest Service, Mark Twain National Forest	X	X			X	
USDA, Natural Resources Conservation Service	X	X	X	X	X	
USDA, Rural Development Agency		X				
U.S. Department of Commerce, Economic Development Administration		X				
U.S. Department of Homeland Security		X				
U.S. Department of Housing & Urban Development		X				
U.S. Department of Transportation		X				
U.S. Environmental Protection Agency		X				
U.S. Geological Services (USGS)	X	X		X		
U.S. Small Business Transportation		X				
Private Stakeholders						
Adventist Community Services		X				
AmeriCorps		X				
American Red Cross		X				
Association of Missouri Electric Cooperative (AMEC)	X	X	X		X	
Callaway Nuclear Power Plant (AUE)	X	X				X
Cooper Plant Nebraska Public Power District (NPPD)-Entergy Support		X				
Kansas City Power and Light (KCPL)			X	X	X	
Missouri Baptist Convention		X				
Missouri Floodplain and Stormwater Managers Association (MSFMA)			X			
Missouri Hospital Association		X				
Missouri Public Health Association		X				
The Salvation Army	X	X				

Participation of the state agencies was defined early in the process. The invite letter requested participation based on needed information, technical knowledge, or other valuable experience to the plan. Representatives were invited via e-mail to attend all the planning process meetings. The kickoff meeting was on November 19, 2012 in Jefferson City, Missouri to get the planning process started.

Further guidance on participation was provided at the planning kickoff meeting along with a general overview of the 2010 plan. The guidance included a schedule of the three planning meetings, and deadlines to return requested information. Additional presentation materials also asked SRMT members to:

- Participate in planning team development of new projects or initiatives
- Record and update the status of mitigation projects their agency is involved with
- Review what their state agency has responsibility for and change as necessary

At the kickoff meeting, the planning team discussed the purpose and requirements of the state plan update, the project's scope of work and schedule, and the responsibilities of the SRMT. Two additional meetings and an online survey for the STAPLEE worksheet of the SRMT were held after the kickoff meeting. Table 2.1.2b lists the dates and purposes of the SRMT meetings during the 2013 update planning process. SEMA sent invitations for all SRMT meetings by email. Agendas, sign-in sheets, and other meeting hand-outs have been compiled in a planning reference file. The results of these meetings are incorporated into the remaining chapters of this plan.

Table 2.1.2b Meetings of the HMPT during the 2013 Plan Update Process

Meeting	Date	Meeting Purpose
1) Kickoff	11/10/2012	• History of Mitigation in Missouri • Review Disaster Mitigation Act planning requirements • Review role of SRMT • The 2013 Update Strategy • Plan Update Timelines
2) Risk Assessment	03/06/2013	• Discuss Methodology and Risk Assessment Summaries for 13 of the 20 Hazards • Review Risk Assessment of State-Owned Facilities • Discuss Hazard Probability and Severity Ratings • Progress on Integrating Local Plans • Updating State Agency Capabilities • Plan Update Timelines
3) Mitigation Strategy	05/16/2013	• Review and Update the Mitigation Strategy including goals, objectives, and actions. • Review results of STAPLEE online survey • Discuss public comment period • Next Steps in the Process

Each agency was engaged and contributed to the planning process. Some examples of these contributions include feedback from the Missouri Department of Natural Resourcs, Water Resources Center (MDNR-WRC) concerning the dam failure hazard risk results and provided updated information to better define this section. There was also input from various agencies at planning team meetings;

direct response from multiple agencies to emails, and phone requests for information related to the process. The results are incorporated throughout this plan as appropriate.

Figure 2.1.2.1 - Photos from the SRMT Planning Meetings

Plan Section Review and Analysis

In the 2013 planning process, the State updated each section of the previously approved plan, including improving organization and formatting of the plan's content. Each section was analyzed using FEMA's state plan update guidance to ensure that it met those requirements. The Emergency Management Accreditation Program (EMAP) standards for mitigation were also considered.

Once a complete first draft of the updated plan was available, SEMA reviewed it. The resulting second draft was distributed via a website to the SRMT for their review and comment. Team members were given from May 17-27, 2013 to comment and provide input. Feedback was received in the form of emailed comments, written comments on the draft, or documents with information relative to the plan or the appropriate agency's section. Feedback was collected and reviewed by the planning contractor and SEMA and incorporated into the plan, as appropriate, to create a third draft for state adoption, which was then submitted to FEMA Region VII for review and approval.

During the review by the SRMT, it was determined that every section of the plan required updating and revision to meet FEMA's state plan update guidance or to change information that was no longer current. Table 2.1.2c briefly summarizes how each section of the plan was reviewed and analyzed to reflect changes that occurred since the previous plan was approved. More detailed documentation on update methodology and process is provided at the beginning of each plan section.

Table 2.1.2c Summary of 2013 Update Review and Analysis of Each Plan Section

Plan Section	Update Review and Analysis
Entire Plan	• This document is a User Interfaced, Web Based Interactive Plan. It has been formatted with active embedded hyperlinks throughout (indicated in blue). Some of the hyperlinks will direct you to a SEMA website to access documentation and research materials compiled. Other hyperlinks will direct the user to a third party website where additional information can be found.
1.0–1.2 Introduction	• Updated language to describe purpose and requirements of the Missouri State Hazard Mitigation Plan update process.
2.0–2.3 Planning Process	• Described planning process for 2013 update, including coordination among agencies and integration with other planning efforts.

Plan Section	Update Review and Analysis
3.0 Risk Assessment	• The chapter has been organized into Sections 3.1 through 3.9.
3.1 Risk Assessment Overview	• Includes data from the State Hazard Analysis, dated December 2012 in Sections 3.1 Risk Assessment Overview 3.2 Identifying Hazards and 3.3 Profiling Hazards. SEMA's Planning and Disaster Recovery Branch updates the Hazard Analysis each October based on the hazard events and disaster declarations from the previous year.
3.2 Identifying Hazards	• This section is divided into 3.2.1 Natural Hazards, 3.2.2 Manmade and Other Hazards, 3.2.3 Presidential Declarations. • Inserted Space Weather and Cyber Disruption have been added hazards. Levee Failure and Severe Thunderstorms as separately profiled hazards. • Updated declarations table and figure as well as tables providing IA and PA costs by disaster. • Added USDA Risk Management Agency insured crop losses for all natural hazards.
	• Incorporated language to indicate that vulnerability assessment/estimating losses will be included for all hazards profiled....not just flood, earthquake, and tornado as it was in 2010. • Updated all hazard profiles to reflect changes from the State Hazard Analysis, dated December 2012. The sections were grouped together to match the hazard types. • Updated Historical Statistics from Stanford University's National Performance of Dams Program; updated probability section based on historical statistics; updated severity section based on dams inventory provided by the Missouri DNR Dam Safety Program; incorporated table listing #s of class 1, 2, and 3 state-regulated dams per county; incorporated maps with total, state-regulated and federal dams. • Levee Failure profile hazard updated and inserted into the probability/severity table. • Severe Thunderstorms profile added and inserted into the probability/severity table. • Hazardous Materials Release has added information to profile regarding numbers and types of hazardous materials spill incidents. Also included numbers of methamphetamine laboratory incidents in 2008. • Mass Transportation Accidents Hazard provided new statistics regarding air travel, railroad, and roadway accidents in Missouri. • Public Health Emergency added information on status of H1N1 pandemic. Figures and tables concerning West Nile virus have been deleted since monitoring for this disease has stopped. • Nuclear Power Plants added demographics concerning the Calloway and Cooper Nuclear Power Plants. • Cyber Disruption profile hazard added and inserted into the probability/severity table. • Space Weather has been included in the utility profile.
3.3 Profiling Hazards	• Updated Nuclear Power Plants Probability to Moderate to reflect change in State Hazard Analysis. • Terrorism included information regarding Missouri's Homeland Security Program. • Utility Failure additional information about space weather. • Attack (Nuclear, Conventional, Chemical, and Biological) Incident has included US WMD reports from the Worldwide Incident Tracking System. • Cyber Disruptions has been updated.
3.4 Overview Analysis of State Development Trends and Assets at Risk	• Described changes in growth and development and examined these changes in the context of hazard-prone areas and how the changes affect loss estimates and vulnerability.

Plan Section	Update Review and Analysis
3.5 Vulnerability Analysis and Estimating Potential Losses by Jurisdiction: State Risk Analysis	• Used Hazus-MH risk assessment for flood by integrating available DFIRM depth grids into Hazus where available for 79 Missouri counties and the independent City of St. Louis. • Used Hazus-MH models to update estimated losses from earthquakes and modeled flood hazards for every county. • Completed vulnerability and risk assessment methodologies to quantify losses for all profiled hazards where data was available. • Updated Table 3.5.1e that summarizes the vulnerability analysis and loss estimation updates.
3.6 Assessing Vulnerability and Estimating Losses by Jurisdiction: Integration of Local Plans	• Reviewed risk assessments from 106 local plans to summarize how local governments ranked hazards in their jurisdictions associated with all natural hazards. This assessment was continued from the 2010 State Plan Update which summarized hazard ranking from local plans . Potential losses reported in local plans as a result of flooding were also summarized in this section.

3.7 Assessing Vulnerability and Estimating Potential Losses of State Owned or Operated Facilities	• This section was greatly expanded in terms of the number of state-owned facilities included in the analysis. For the 2013 State Mitigation Plan, this section analyzed 17,364 geolocated state-owned facilities. This is 70% more facilities than was used for the 2010 update. For this 2013 update the following state-owned facilities inventories were included:
	  • 14 State Department's facilities and infrastructure were included in this data set.
	  • Almost 4,000 geolocated Office of Administration facilities are inventoried in GIS format and included in the analysis.
	  • Over 10,361 of Missouri State Bridges are inventoried in GIS format and included in the analysis.
	  • Over 175 geolocated MoDOT facilities are inventoried.
	  • 89 geolocated Department of Higher Education/Public Colleges and Universities are inventoried in GIS format and included in the analysis
	• Vulnerability overview analysis and loss estimates were provided for all the profiled hazards where data was available

4.0 Mitigation Strategy	• Updated 4.0 based on the results of the updated risk assessment, data from the local plans, completed mitigation actions, and implementation obstacles and opportunities over the last three years.
4.1 Goals and Objectives	• Reviewed goals and objectives from the last plan and concluded that they were still representative of the state's mitigation strategy. • Presented goals and objectives to the SRMT Meeting on May 16, 2013for input and ideas.
4.2 State Capability Assessment	• Updated the state capabilities, both pre and post disaster, and how these capabilities have changed since the previously approved plan. • Discussed changes in state funding capability and the State's policies addressing development in hazard-prone areas.
4.3 Local Capability Assessment	• Reviewed capability assessments in local plans to develop a general description of local capabilities. • Analyzed effectiveness of local capabilities based on the SRMT expertise.
4.4 Mitigation Actions	• Reviewed mitigation actions M1-M11 from the last plan and determined they all remain applicable. • Documented progress of actions since the previously approved plan and identified new actions. • Presented mitigation actions at SRMT meeting on May 16, 2013, for input and ideas.
4.5 Funding Sources	• Identified funding sources used since previously approved plan. • Updated primary funding sources with more detail and updated list of other potential funding sources.

Plan Section	Update Review and Analysis
4.6 Severe Repetitive Flood Loss Strategy	• Updated this element into Chapter 4 • Described the State's Severe Repetitive Flood Loss Strategy
5.0 Coordination of Local Mitigation Planning	• Reviewed process for and progress in coordinating local mitigation planning. • Updated information on the status of local plan completion.
5.1 Local Funding and Technical Assistance	• Described how the State provided planning and technical assistance to local governments over the last three years. • Updated the process for providing local assistance to focus resources on the local plan update process. • Summarized current status of counties with completed and approved local plans, those in process, and those without plans.
5.2 Local Plan Integration	• Described how local risk assessments, goals and objectives, mitigation actions, and capabilities were integrated into the updated state plan. • Assessed the challenges and success of this integration.
5.3 Prioritizing Local Assistance	• Reviewed criteria for prioritizing communities and local jurisdictions that would receive planning and project grants and determined it should remain the same.
6.0–6.2 Plan Maintenance Process	• Reviewed procedures for monitoring, evaluating, and updating the plan and determined that no changes were required.
7.0–7.6 Enhanced Plan	• Reviewed and revised sections based on FEMA's guidance for enhanced plan updates. • Improved integration of enhanced plan information with other sections of the plan. • During this update process, the State increased the capability to track loss avoidance as a result of implemented mitigation measures. This resulted in the continued use of a web-based tool which is described in detail in Chapter 7. Including the effectiveness of the the program.

2.2 Coordination among Agencies

Requirement §201.4(b):	The [State] mitigation planning process should include coordination with other State agencies, appropriate Federal agencies, and interested groups.

The State recognizes the importance of coordinating with local, state, and federal agencies and other interested groups involved in hazard mitigation in the planning process for the update of the Missouri State Hazard Mitigation Plan. This coordination is necessary to enhance data collection, mitigation strategy development, plan implementation, and overall investment in Missouri's mitigation program. For the 2004, 2007, 2010 and 2013 planning efforts, the State involved other agencies through the State Hazard Mitigation Planning Team (SHMPT) and State Risk Management Team (SRMT), and follow-up phone conversations and email communication with key planning team members. One addition to the process established in 2007 included the introduction of the EMAP mitigation standards to the other agencies on the team so that they understand their role in meeting and upholding those standards. This was included as part of the 2013 state plan update.

As the agency designated by the Missouri Governor to coordinate statewide emergency preparedness, response, recovery, and hazard mitigation activities, SEMA works with other state, federal, and local agencies to develop and implement the strategies outlined in this document, obtain interagency

feedback on the mitigation steps taken, and use of information to update this plan. SEMA acted as the coordinator of and participant on the SRMT during the planning process for the previously approved plans and for the 2013 update.

The previous section, Section 2.1 Documentation of Planning Process, listed the private stakeholders that participate on the SRMT for the 2013 plan update. These stakeholders of the SRMT were kept involved in the update process by being invited to the three planning meetings, attending planning meetings when available, being sent emails of the meeting minutes, providing data and information, and commenting on the draft version of the plan. The SRMT relied on these stakeholders, in particular the Missouri Association of Councils of Governments (the RPCs) to disseminate information within their districts to interested businesses and private interested parties. SEMA also participated in interagency flood mitigation activities such as the “Interagency Levee Task Force” after the floods of 2008 and is a member of the new interagency Regional Flood Risk Reduction Team. Both of these groups were initiated by the U.S. Army Corps of Engineers and supported by various states, FEMA, the NWS, NRCS and others. Comments from previous reviews of the 2013 plan from FEMA Region VII and FEMA headquarters were also incorporated into this update.

As hazard mitigation planning continuously involves multiple government agencies, private voluntary organizations, and commerce and industry, it is assumed the role of other entities in updating this plan will increase over time. This plan will be adjusted accordingly to reflect new participants and their roles during the next review process. The attendance of state agency representatives to the planning meetings and coordination among agencies increased for this 2013 plan update. Missouri agency representatives understand the importance of this planning process and having an approved State Mitigation Plan in Missouri.

2.3 Integration with Other Planning Efforts

Requirement §201.4(b):	[The State mitigation planning process] should be integrated to the extent possible with other ongoing State planning efforts as well as other FEMA mitigation programs and initiatives.

The State of Missouri is fully committed to an effective and comprehensive mitigation program. Missouri is somewhat unique in that the Hazard Mitigation Grant Program (HMGP), Flood Mitigation Assistance Program (FMAP, Pre-Disaster Mitigation Program (PDM), Repetitive Flood Claims (RFC), Severe Repetitive Loss (SRL), floodplain management, Earthquake Program, and mitigation planning are all the direct responsibility of SEMA. In order for these programs to achieve their full potential, state activities should complement appropriate mitigation goals and strategies. The best way to accomplish this is to ensure that mitigation goals and initiatives are integrated to the extent possible into all planning activities for federal, state, and local governments. Over the years, the works of these various entities have been incorporated into the Missouri State Hazard Mitigation Plan as well as planning activities of other state agencies.

Mitigation is considered, where possible by Missouri statutes, in the earthquake plans of the Departments of Transportation; Insurance, Financial Institutions, and Professional Registration; Corrections; Natural Resources; Education; the Office of Administration; the Public Service Commission;

Missouri Seismic Safety Commission; Missouri Emergency Response Commission; and others. The Department of Transportation considers mitigation, especially floodplain management and open-space issues, in their transportation plans. The Department of Conservation has partnered with SEMA in developing streambank stabilization planning to help mitigate flooding problems in communities such as Piedmont, Missouri.

The results of the expanded vulnerability analysis of state-owned facilities in this Mitigation Plan Update have been provided to the Office of Administration, Department of Higher Education, Department of Transportation, and Missouri Department of Conservation (inventories from these sources constitute the full inventory of state-owned facilities in Missouri). For those facilities for which GIS data was provided, the State agencies have been provided with the results indicating specific facilities potentially at risk to inundation from failure of state-regulated dams, flooding from a 100-year flood event, and damage from an earthquake event with a 2% probability of exceedance in 50 years. Provision of this data is provided specifically so that those State-agencies are made aware of potential risks to determine if mitigation opportunities are necessary and/or feasible. Section 3.7 provides additional details as well as password protected hyperlinks to facility-specific risk information.

During the 2013 plan update, the State Hazard Mitigation Planning Team (SRMT) reviewed the mitigation-related plans and programs of other State agencies. Since response and recovery plans and programs also typically have a mitigation component, the SRMT also incorporated those plans in this review. The purpose of this review was to identify changes, updates, and/or additions since the 2013 Mitigation Plan update to incorporate relevant data and capabilities into the mitigation plan and to better understand areas where mutual responsibilities and policies could be leveraged. Examples of mitigation-related plans and programs of other State agencies participating on the SRMT are provided in Section 4.2.1.

2.3.1 Integration of Local Plans

SEMA is the primary state coordinating agency for all local hazard mitigation plans. The Logistics, Resources, Mitigation and Floodplain Management Branch is responsible for working with local governments to develop, review, and update local hazard mitigation plans and integrate them with the state plan. As of April 2013, 85 of 114 Missouri counties had approved hazard mitigation plans that meet the requirements of both the Disaster Mitigation Act of 2000 and the Flood Mitigation Assistance Program. Included in this number are 9 counties that have completed their first plan or updated their plan since 2010. Another 28 counties (including the St Louis City) are in the process of updating their plan and/or in process of their first plan.

It is understood by all levels of government that the success of the Missouri mitigation program depends on the degree to which everyone works together toward the common goal of reducing future disaster losses in Missouri. It is also widely acknowledged that the local plans can benefit from data in the state plan, and the state plan can benefit from data in local plans. For this plan update, the SRMT reviewed, summarized, and incorporated information from the local plans. This information included hazard identification and risk assessment, goals and objectives, local capabilities, and mitigation initiatives. More information about the integration of local plans is in Section 3.6 Assessing Vulnerability and Estimating Losses by Jurisdiction: Integration of Local Plans and Section 5.2 Local Plan Integration.

2.3.2 Integrating Planning Information with Other Mitigation Partners

The Missouri State Hazard Mitigation Plan Update identifies Missouri's hazards, risks, vulnerabilities, goals, objectives, priorities, and strategies for mitigation. The plan is the basic document that SEMA uses to focus efforts to improve the lives of Missouri residents. Over the years, SEMA has worked continuously to identify partners (federal, state, local, and non-profit entities) interested in participating in the State's mitigation efforts.

Integration of federal, state, and local agencies; and private non-profit organizations into the state mitigation program has been an ongoing process that has helped educate these agencies and organizations about the importance of mitigation. This educational process resulted in use of mitigation in their programs and plans over time. These discussions and/or meetings have involved reviews of current programs and policies that promote or could potentially promote mitigation initiatives throughout the State and reviews of existing and proposed plans to identify mitigation opportunities. Many of the mitigation successes since the Great Flood of 1993 have been a direct result of these meetings. The lessons learned through these programs and activities have contributed to the development of this plan and have been integrated into separate plans and programs.

This Missouri State Hazard Mitigation Plan is available to all state agencies to reference when seeking information and guidance on state mitigation goals and objectives.

SEMA also works to implement the components of this plan by being a part of the SRMT and working with the state agencies that participate on the Missouri Seismic Safety Commission, state agencies that help develop mitigation measures associated with Public Assistance projects, and state educational institutions that participate in the mitigation program.

In addition to working with FEMA in all aspects of hazard mitigation projects and plans, SEMA has worked with multiple other federal mitigation partners to integrate mitigation into projects and plans. The Natural Resources Conservation Service (NRCS) and U.S. Army Corps of Engineers provided input and advice on several mitigation initiatives in the State regarding retention/detention basins.

The successful combination of SEMA buyouts and NRCS retention basins in the City of Neosho, a Project Impact Community, is an excellent example of the NRCS' support. An NRCS feasibility study led the City of Piedmont to develop several flood buyout programs to mitigate flooding over time and Project Impact Disaster Resistant Community status. Piedmont also worked with the Missouri Department of Conservation to reduce flooding through creek cleanup and streambank stabilization activities and plans. In addition, Piedmont and the City of Maryville worked with the Economic Development Agency, using SEMA's hazard mitigation planning process, to develop communitywide business plans for disaster survivability. The City of Hannibal (another Project Impact community) followed Piedmont's creek cleanup lead and conducted similar activities.

SEMA has supported efforts to reduce damages from storms, such as the project undertaken by the City of Independence to bury electric service lines to homes that were damaged by the severe Ice Storm of 2002. SEMA's work with the City of Bolivar (a Project Impact community) by helping the city procure and issue NOAA weather warning radios to local schools, nursing homes, day care centers, and college dormitories.

Approximately 652 Missouri communities participate in the National Flood Insurance Program (NFIP) and five participate in the Community Rating System (CRS). The SEMA Floodplain Management Section of the Logistics, Resources, Mitigation and Floodplain Management Branch conducts approximately 26

workshops each year promoting the NFIP to nonparticipating communities. Additional workshops are conducted to promote the CRS. These workshops have been instrumental in increasing the number of communities participating in both of these programs.

The National Weather Service (NWS), the electric cooperatives, and private businesses combined their resources to support the coverage expansion of the State's weather radio transmitters. In four years, this project expanded weather radio coverage to include almost the entire state.

SEMA supports the NWS StormReady program and its many mitigation measures in Missouri. As of May 28, 2013, Missouri had 20 counties, 41 communities, two commercial sites, and four universities, and 14 supporters that are recognized as StormReady.

The Missouri Department of Economic Development's Community Development Block Grant Program (CDBG) has complemented the SEMA buyout program in removing homes and businesses from the flood hazard areas throughout the State. The SEMA program has concentrated primarily on family residences, while the CDBG program has included businesses and some residences. Together, these programs have made a significant impact on the overall vulnerability of individuals to flooding as well as reducing the costs of future flooding.

Other partners and projects include the following:

- The U.S. Army Corps of Engineers has worked with SEMA on several levee projects, the Silver Jackets program, and requests for channelization projects
- The Missouri Department of Conservation has worked with SEMA on endangered species and fish and wildlife management issues associated with flood buyouts and water management and conservation questions
- The Missouri Department of Agriculture works with SEMA on agriculture and drought issues and planning, including ways to mitigate damage
- The Missouri Department of Insurance, Financial Institutions, and Professional Registration supports SEMA in promoting flood and earthquake insurance, preparedness, response, and mitigation issues and plans
- The Missouri Department of Natural Resources has worked with SEMA on flood buyouts, hazardous material planning, earthquake mitigation, and dam safety plans and issues
- The Missouri Department of Transportation, the U.S. Department of Transportation, and the Federal Highway Administration have worked with SEMA on flood buyouts, open-space restriction issues, and earthquake planning and bridge retrofits
- In addition to the state and federal transportation agencies, the U.S. Geological Survey; Central U.S. Earthquake Consortium; DNR; Missouri Department of Insurance, Financial Institutions, and Professional Registration; Missouri Seismic Safety Commission; Missouri Structural Assessment and Visual Evaluation (SAVE) Coalition (members include the American Council of Engineering Companies/Missouri, American Institute of Architects/Missouri, American Society of Civil Engineers, Missouri Society of Professional Engineers, Structural Engineers Association of Kansas and Missouri, University of Missouri–Rolla School of Civil Engineering and Natural Hazards Mitigation Institute, Saint Louis University Earthquake Center, Washington University, Southern Illinois University–Edwardsville, University of Memphis Center for Earthquake Research and Information, and Earthquake Engineering Research Institute New Madrid Chapter) work with

SEMA on earthquake mitigation, including retrofits, public education, soil mapping, and seismic studies
- Several Missouri businesses and business associations have worked with SEMA and local communities on disaster mitigation and business continuity planning
- SEMA's statewide volunteer coordinator has worked for years to educate local, state, and national voluntary organizations through the Disaster Recovery Partnership, Community Organizations Active in Disaster, and the Missouri Voluntary Organizations Active in Disaster about the importance of mitigation
- SEMA's staff served on the State American Red Cross mitigation committee

SEMA has identified many instances where the information contained in this Missouri State Hazard Mitigation Plan Update could be and has been integrated into the planning of state and federal departments, local governments, universities, businesses, and private associations.

The general information in this plan is intended for use by interested local governments, universities, businesses, and private associations, in addition to state and federal departments and agencies.

2.3.3 Challenges in Planning Integration

This 2013 update reflects the successful integration of 92 percent of the county-level plans, which equates to coverage for 97 percent of Missouri's population. Since Missouri has 115 counties (including St. Louis City) and 961 incorporated cities, towns, and villages, SEMA was challenged with how to effectively and efficiently develop plans for each of the jurisdictions. SEMA streamlined the process by encouraging local governments to participate in multi-jurisdictional county-level plans, which reduced the number of plans that needed to be reviewed and integrated and brings local communities together to focus on mitigation.

By providing local mitigation planning guidance and HAZUS county-level flood results for detailing form and content requirements, SEMA had hoped to further streamline the integration of local plan data into the state plan while allowing for local flexibility. While it did prove to be a successful tool (as evidenced by the high number of plans approved), local risk assessments used different methods and interpretations to determine vulnerability and different measures to assess risk based on the various levels of data availability. Therefore, it was challenging to compare the counties to see where one might be more vulnerable to a particular hazard than another. (More information about the challenges of the local risk assessment integration can be found in Section 3.6 Assessing Vulnerability and Estimating Potential Losses by Jurisdiction: Integration of Local Plans, Section 4.1 Hazard Mitigation Goals and Objectives, Section 4.3 Local Capability Assessment, and Section 4.4 Mitigation Actions.) This link provides access to all local hazard mitigation plans in Missouri that have been approved by FEMA.

Traditionally, the State of Missouri has had great success in integrating with other state planning efforts as well as FEMA mitigation programs and initiatives. Challenges in integration that exist relate to lack of staff, meeting schedule conflicts, lack of travel funds for meetings, and lack of time to focus on other plans and programs in addition to daily work duties.

More information on integration with other planning efforts can be found in Section 4.2 State Capability Assessment; Section 4.4 Mitigation Actions, Table 4.9 Missouri Mitigation Action Categories Strategy Overview; Section 5.2 Local Plan Integration, and Section 7.1 Integration with Other Planning Initiatives.

3.1 Risk Assessment Overview

Much of the introduction to this chapter as well as Sections 3.2 Identifying Hazards and Profiling Hazards come from the State Hazard Analysis, which is developed by SEMA's Planning and Disaster Recovery Branch and is updated each October. The State Hazard Analysis meets multiple objectives and provides direction in hazard mitigation and disaster response for the State and local emergency operations plans and hazard mitigation plans. The most recent Hazard Analysis dated December 2012 was utilized for this update to the State Hazard Mitigation Plan. (http://sema.dps.mo.gov/newspubs/publications/hazard_analysis.asp). Some modifications were made to the text for the purposes of this mitigation plan. In addition, the profile sections for Levee Failure, Land Subsidence, and Cyber Disruption were developed specifically for this Mitigation Plan as those hazards were not included as separate hazards in the State Hazard Analysis. The Dam Failure profile section was developed independent of the State Hazard Analysis during the 2010 State Hazard Mitigation Plan update, as the 2009 State Hazard Analysis update was not available to utilize at that time. Tornadoes and Severe Thunderstorm are treated separately in the Mitigation Plan, whereas they are a single hazard in the State Hazard Analysis. Finally, the Heat Wave section of the State Hazard Analysis forms the basis for the renamed Mitigation Plan hazard of Extreme Temperatures.

Lately, disasters appear to be occurring more frequently than during previous years. Federal, state, and local emergency managers need to prepare for, respond to, and recover from the increasing frequency and scope of disasters. While recent major disasters are memorable, the increased rate of occurrence is remarkable. Disasters in the 1990s were nearly twice as frequent as disasters in the 1980s. The decade beginning in 2000 then saw more than twice the number of major disasters as experienced in the 1990s, a more than fourfold increase over the 1980s. Since 2010, Missouri has seen 4 major disaster declarations, including the devastating tornado outbreak that decimated the Town of Joplin. According to some weather forecasters, the country has entered a period of extremely destructive weather patterns. Recent advances in the study and tracking of climate change seem to support this point. Noting this fact, the 2013 plan update ensured that the subject of climate change was integrated early on in the planning process. A new section devoted to this subject has also been added to this plan.

Also, the emergency management community now faces threats in many ways different than past threats. Gone are the days when emergency management was only for natural disasters and nuclear preparedness. We now face more technological and political-based hazards that demand the attention of the emergency management community. These manmade and technological hazards include a number of threats that have not been adequately dealt with in the past, including hazardous materials releases, civil disorders, and terrorism.

This document has been compiled to identify the multiplicity of hazards that exist at varying locations and degrees of magnitude throughout the State and to determine the potential impacts of these hazards on residents, property, and the environment. The information contained herein identifies capabilities essential to disaster response, for determining the probable effectiveness of allocating resources in emergency situations, and for encouraging the cooperation of various political subdivisions and emergency services in formulating regulations, plans, and programs to prepare for disasters and minimize loss of life, human suffering, and damage to public and private property. In addition, a thorough hazard analysis provides a foundation for educating senior government officials and the public on dangers posed by various hazards. The foundation for emergency preparedness is planning how to handle disasters. The art of perfecting how to respond to disasters is enhanced by the ability to bring together the key players for periodic exercises that emulate actual disasters.

The State Hazard Mitigation Plan provides a basis for activities proposed during the State's planning efforts and should be used by state and local officials to plan and prioritize resource allocations. Local officials can use information in this document to develop their own localized hazard analysis.

Technical Note*: This document is a User Interfaced, Web Based Interactive Document. It has been formatted with active embedded hyperlinks throughout. There are several different types of hyperlinks.*

Hyperlinks within the document: Some of the hyperlinks will direct the user to specific sections of the plan where referenced information may be found. The section heading hyperlinks provided below and the sub-section hyperlinks at the beginning of complex sections allow the user to go to a specific section or sub-section of the risk assessment. In addition, throughout the text, hyperlinks take the user directly to referenced tables, figures, or sections. These links are identified by a blue color format.

Hyperlinks to SEMA website: Some of the hyperlinks will direct the user to a SEMA website to access referenced documents and resource data. Some of these documents are password protected and the user will be directed to obtain credentials from SEMA to gain access. These links are identified by a red color format.

Hyperlinks to external websites: These hyperlinks will direct the user to a third party website where additional information can be found. As with all hyperlinks to external sites, if the site administrator makes changes to the URL, these can expire or become non-functional. These links are identified by a green color format.

3.2 Identifying Hazards

Requirement §201.4(c)(2)(i):	[The state risk assessment shall include an] overview of the type…of all natural hazards that can affect the state.

3.2.1 Natural Hazards

3.2.2 Manmade and Other Hazards

3.2.3 Presidential Declarations

Because Missouri is located in the middle section of the United States, it is prone to several kinds of natural hazards. Missouri has a continental climate; in other words, the weather is changeable and has large variations in temperature and precipitation.

Missouri serves as a major thoroughfare for transportation and has an abundant share of industrial, agricultural, and recreational facilities. Thus, manmade disasters can occur, such as hazardous materials releases, fixed nuclear facility incidents, and other emergencies caused by human action.

Missouri has four topographically distinct regions: glaciated plains in the north, plains or prairie in the west, lowlands in the extreme southeast, and the Missouri Ozarks in between.

The plains section, both glaciated and unglaciated, encompasses nearly all the area north of the Missouri River and a large area south of the river in the western part of the State. The topography varies from rolling hills in the east to hills in the west that average about 450 feet above sea level. There are numerous wide, flat valleys cut by the river.

The Ozarks, which comprise about half of the State, are characterized by rugged areas of sharp ridges and deep narrow valleys. Elevations range from about 1,000 to more than 1,600 feet above sea level. The southeastern lowlands cover about 3,000 square miles, with elevations from 230 to 300 feet above sea level. Much of the region is excellent farmland, channeled by an extensive system of drainage ditches.

Because the State is situated along two of the continent's greatest rivers, the Missouri and the Mississippi, the potential for great floods is high. While six large flood control dams have been built on the main stream of the Missouri River, they have not eliminated the flood threat.

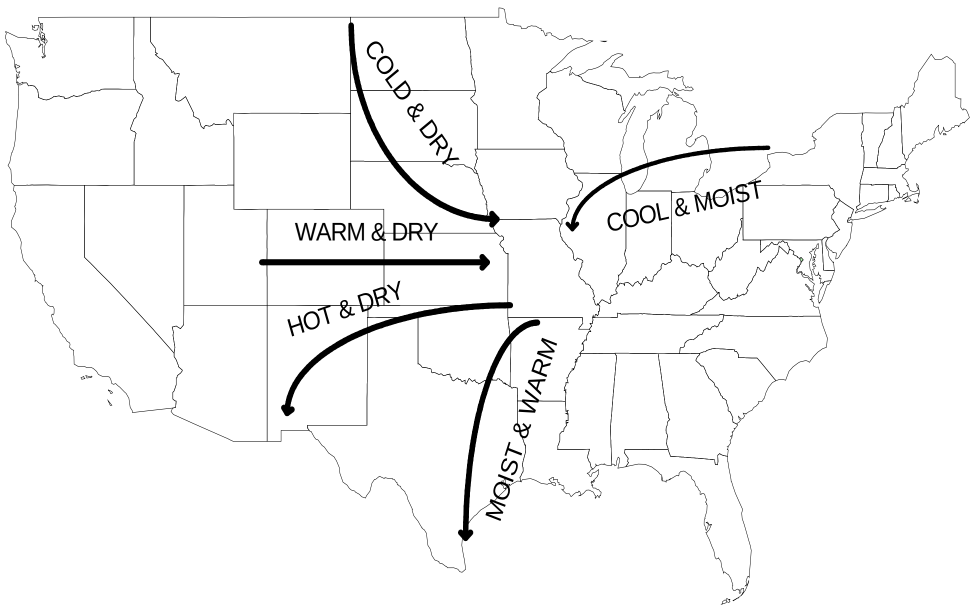
Warm and cool air masses often collide along sharply divided fronts, accompanied by violent thunderstorms having intense rains, strong winds, hail, lightning, and tornadoes. These frontal storm systems can pass across the State at any time of the year, but are most frequent during the spring months (March, April, and May). There are two important truths about Missouri's weather: (1) the State is subject to weather extremes, and (2) extreme weather changes can occur rather quickly.

Most of the natural disasters that occur in Missouri (except for earthquakes, land subsidence, and possibly dam failures) result from a weather extreme or an extreme weather change. Because Missouri is situated in the center of the United States, it is subject to many different influences that determine weather patterns.

According to Dr. Grant Darkow, Department of Atmospheric Science at the University of Missouri-Columbia, specific recognizable weather patterns are responsible for Missouri's weather, especially those that "tend to produce extremes in precipitation, resulting in unusually wet or drought conditions, and extremes in temperature, either abnormally warm or cold." Darkow explains:

> The character of air over Missouri on any particular day or series of days is dominated by the source regions from which it comes. Missouri's mid-continental location makes it subject to air flows from a variety of source regions with markedly different properties.
>
> The state is close enough to the Gulf of Mexico that warm air with high humidity can flow into the state from a southerly direction at almost any time of the year. This warm, moist air is the principal source of spring, summer, and fall precipitation and, occasionally, precipitation in winter as well.
>
> In contrast, air arriving over Missouri from semi-arid to arid regions to the southwest is warm or hot and usually dry. Air that has moved from west to east over the Rocky Mountains arrives warm and dry, having lost most of its low-level moisture as it climbed the west side of the mountains.
>
> Abnormally cold air in the winter and cold summer air with only very small moisture content arrives over Missouri from the northwest or north, whereas air entering Missouri from the northeast will tend to be cool and moist.

Figure 3.2.1 - Source Regions and Atmospheric Characteristics for Air Arriving in Missouri



Darkow goes on to explain:

> Normally, the flow from one of the principal source regions will last for two or three days before switching to a different direction and source region. These transitions typically are accompanied by a frontal passage during which the change in wind direction, temperature, and moisture content, or any combination, is concentrated.
>
> In some instances, however, a particular flow pattern may be very persistent or dominant for a period of weeks or even months. These periods can lead to wet, dry, hot, or cold spells, and the extremes associated with these periods. These periods are characterized by particular upper air flow patterns and associated surface weather patterns (see Figure 3.2.2, 3.2.3, 3.2.4, 3.2.5, 3.2.6, 3.2.7, that were taken from the State Hazard Analysis).

Figure 3.2.2 - Upper Air Pattern

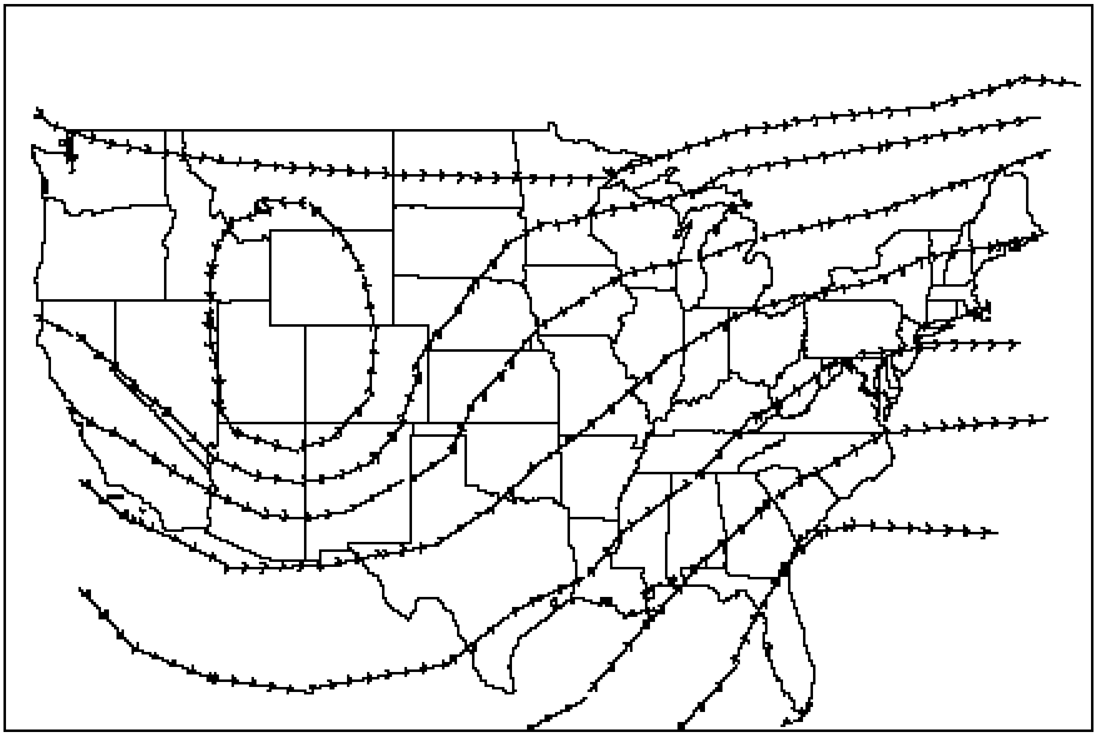


Figure 3.2.3 - Surface Air Pattern

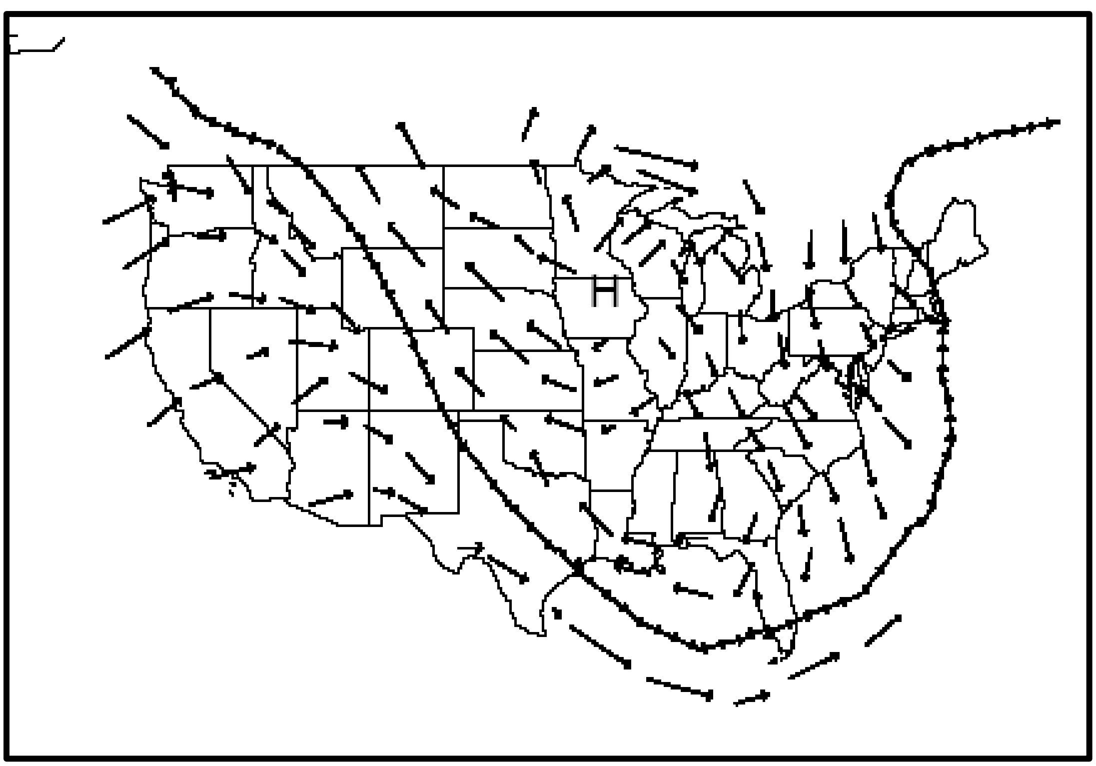


Figure 3.2.4 - Upper Air Pattern

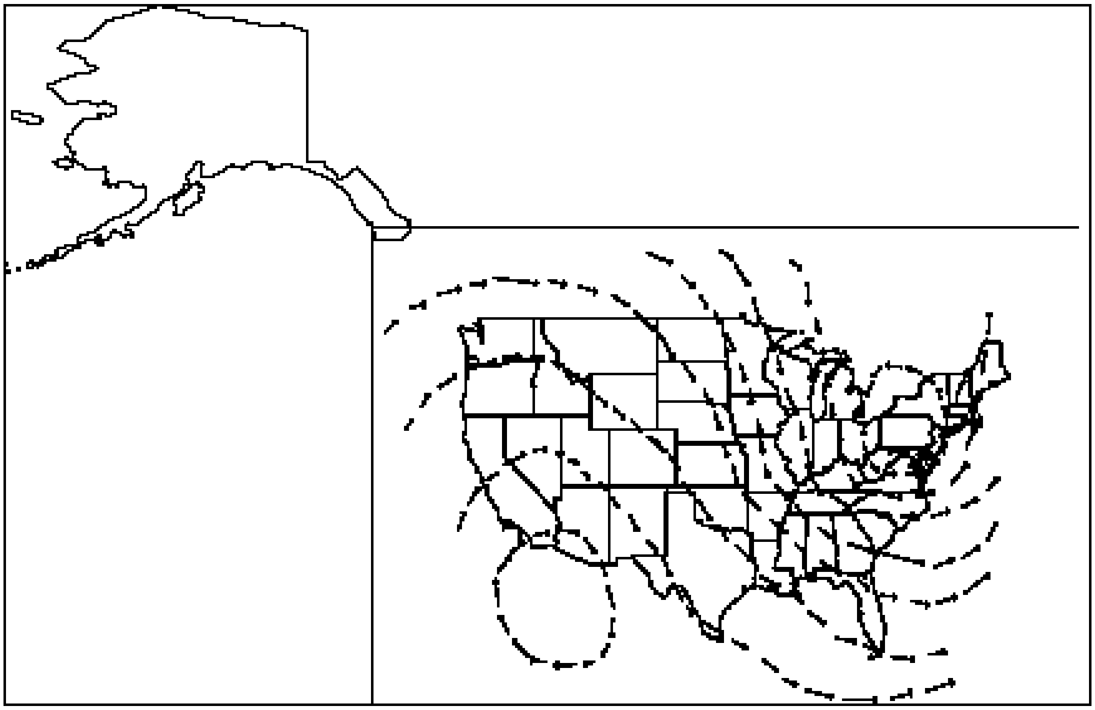


Figure 3.2.5 - Surface Air Pattern

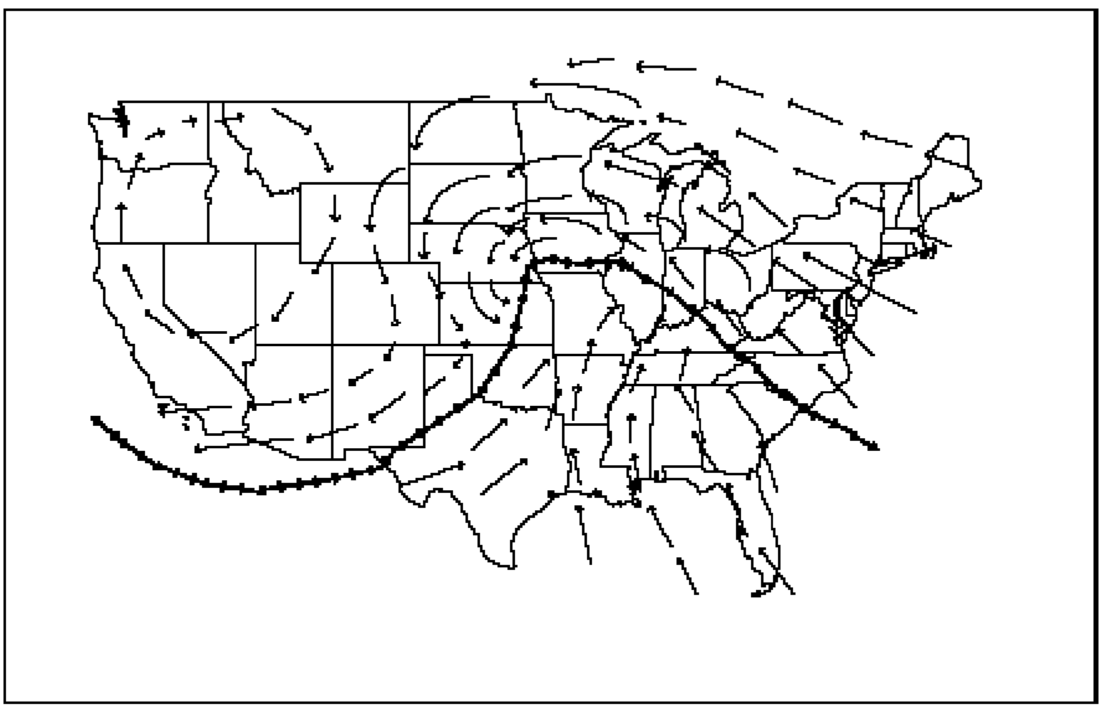


Figure 3.2.6 - Upper Air Pattern

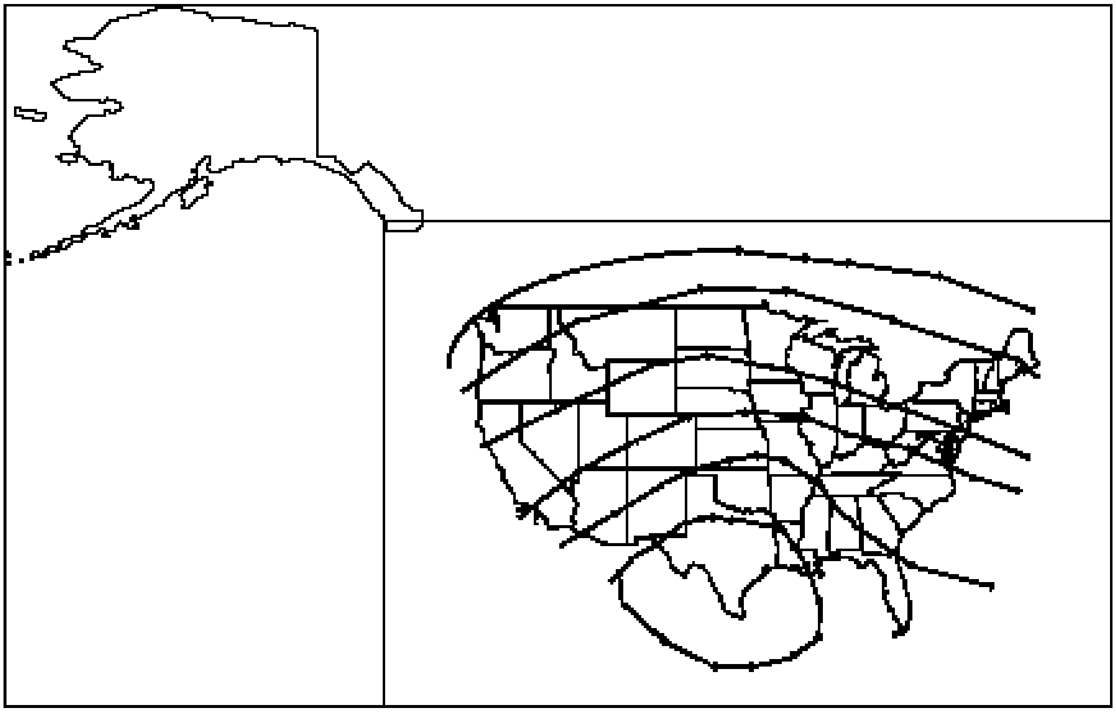
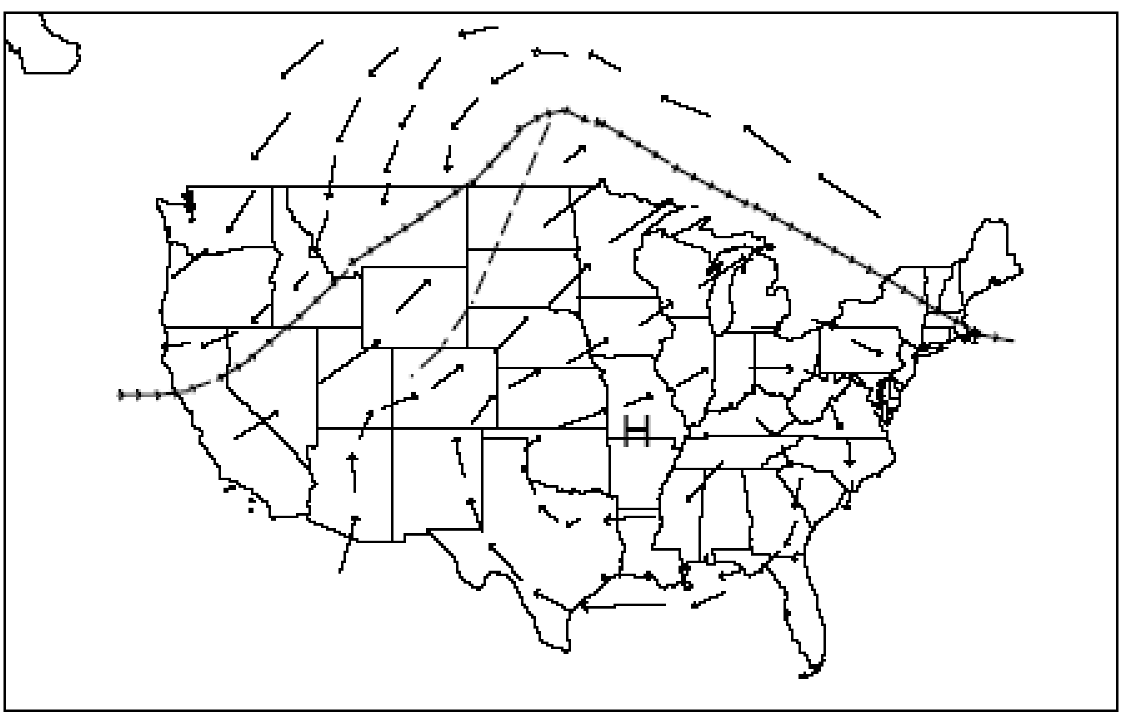


Figure 3.2.7 - Surface Air Pattern



> The persistence of these weather patterns and the possible resulting condition is the subject of several of the natural disasters discussed in this study. Specifically, floods, droughts, fires, heat waves, severe cold, and winter storms can be the result of the persistence of one of these weather patterns, whereas tornadoes can represent the outgrowth of rapid shifts in weather patterns. Knowing these patterns may assist in alerting disaster planners and the general public to the possibility of a developing emergency situation.

This State Hazard Mitigation Plan considers natural, manmade, and other hazards, as discussed in the following sections.

3.2.1 Natural Hazards

Natural hazards can be complex, occurring with a wide range of intensities. Some events are instantaneous and offer no window of warning, such as earthquakes. Some offer a short window in which to alert the public to take actions, such as tornadoes or severe thunderstorms. Others occur less frequently and are typically more expansive, with some warning time to allow the public time to prepare, such as flooding. The following natural hazards threaten Missouri. It should be stressed that they are listed in groupings of similar hazards for ease of reference. The list below is not intended to represent hazard rankings:

- Riverine Flooding (Major and Flash)
- Dam Failure
- Levee Failure*
- Earthquake
- Land Subsidence / Sinkholes
- Severe Thunderstorm (Damaging Winds, Hail, and Lightning)*
- Tornadoes
- Severe Winter Weather (Snow and Ice)*
- Drought
- Extreme Temperatures**
- Fires (Structural, Urban, and Wild)

* Note: added in 2010 as separate hazards. In the 2007 update, levee failure was included in the riverine flooding hazard and severe thunderstorm was included in the hazard discussion with tornadoes.

** Note: altered in 2013. In the 2010 update, extreme cold was included in the severe winter weather hazard and heat wave was its own hazard.

During the planning process for the 2013 plan update, it was determined to expand the heat wave hazard to encompass both hot and cold temperature extremes. The resulting, renamed, extreme temperatures hazard incorporated some extreme cold information that was previously contained in the severe winter weather hazard.

During the planning process for the 2007 plan update, it was noted that levee failures may warrant profiling as a separate hazard in future updates to this plan. As a result, levee failure was profiled as a separate hazard in the 2010 update. It should be noted that SEMA did not profile levee failure separate from riverine flooding in the 2009 Hazard Analysis update.

It was also noted during the 2007 update process that severe thunderstorms and associated sub-hazards should be profiled separately from tornadoes. Although SEMA did not profile these hazards separately during the 2009 update to its Hazard Analysis, the planning team chose to profile severe thunderstorms separate from tornadoes in the 2010 update to the mitigation plan. The frequency of damages caused by severe thunderstorms across the State necessitates that this hazard be discussed separate from the less frequent albeit devastating tornado hazard.

The following natural hazards are not included in this analysis because they historically have not threatened Missouri: avalanches, coastal erosion, coastal storms, hurricanes, tsunamis, and volcanoes. Although in 2008 Hurricane Ike did indirectly cause severe weather in the state, it was the resulting hazards (flooding, winds, hail, and tornadoes) that directly affected Missouri. While expansive soils,

landslides, and rockfalls are recognized as hazards in Missouri, they occur infrequently and their impacts are minimal; so they will not be profiled further in this document.

3.2.2 Manmade and Other Hazards

Each year there are increases in manmade incidents, which can be just as devastating as natural disasters. The following hazards could also affect Missouri:

- CBRNE Attack (Chemical, Biological, Radiological, Nuclear, and Explosive)
- Civil Disorder
- Cyber Disruption*
- Hazardous Materials
- Mass Transportation Accidents
- Nuclear Power Plants (Fixed Nuclear Facilities)
- Public Health Emergencies/Environmental Issues
- Special Events
- Terrorism
- Utilities (Interruptions and System Failures)

* Note: added in 2013 as new hazard.

During the planning process for the 2013 plan update, it was noted that cyber disruption warranted profiling as a new hazard, based upon the possible probability and severity of that type of event.

3.2.3 Manmade and Other Hazards

In the United States, 95 percent of all presidentially declared disasters have been related to weather or flood events. In Missouri, 100 percent of the presidentially declared disasters since 1975 have also been related to weather or flood events. Between the 2007 and 2010 updates of the Mitigation Plan, there were 13 declared disasters. Of these 13 disasters, 11 were Presidential disaster declarations and 2 were emergency disaster declarations. Between the 2010 and 2013 Mitigation Plan update there were 4 Presidentially declared disasters, including the severe storms that produced the damaging tornado that hit Joplin.

Table 3.1.3a summarizes presidential declarations for Missouri since 1975. Additional information on declared disasters can be found at http://www.fema.gov/news/disasters.fema.

Table 3.1.3a Disaster Declarations for Missouri from 1975 to 2013

Declaration Date	Disaster No.	Incident Type	No. of Counties Designated	Type of Assistance By County*
Presidential Disaster Declarations				
May 3, 1975	DR 466	Tornadoes, High Winds, Hail	4	IA & PA
July 21, 1976	DR 516	Severe Storms, Flooding	4	IA & PA
May 7, 1977	DR 535	Tornadoes, Flooding	7	IA & PA
September 14, 1977	DR 538	Severe Storms, Flooding	6	IA & PA
April 21, 1979	DR 579	Tornadoes, Torrential Rain, Flooding	17	IA Only: 1

Declaration Date	Disaster No.	Incident Type	No. of Counties Designated	Type of Assistance By County*
				IA & PA: 16
May 15, 1980	DR 620	Severe Storms, Tornadoes	1	IA Only
August 26, 1982	DR 667	Severe Storms, Flooding	3	IA Only: 1 IA & PA: 2
December 10, 1982	DR 672	Severe Storms, Flooding	17	IA Only: 18 PA Only: 1 IA & PA: 5
June 21, 1984	DR 713	Severe Storms, Flooding	11	IA Only: 1 PA Only: 8 IA & PA: 2
October 14, 1986	DR 779	Severe Storms, Flooding	30	IA Only: 7 PA Only: 15 IA & PA: 8
May 24, 1990	DR 867	Flooding, Severe Storm	10	IA Only: 2 IA & PA: 8
May 11, 1993	DR 989	Severe Storm, Flooding	8	IA Only
July 9, 1993	DR 995	Flooding, Severe Storm	101 & St. Louis City*	IA Only: 14 IA & PA: 88
December 1, 1993	DR 100 6	Flooding, Severe Storm, Tornadoes	24	IA Only: 10 IA and PA: 14
April 21, 1994	DR 1023	Severe Storm, Flooding, Tornadoes	17 & St. Louis City*	IA Only
June 2, 1995	DR 1054	Severe Storm, Tornadoes, Hail, Flooding	61 & St. Louis City*	IA Only: 19 IA & PA: 43
October 14, 1998	DR 1253	Severe Storm and Flooding	19	IA and PA: 5 PA Only: 14
October 19, 1998**	DR 1256	Severe Storm and Flooding	2 & St. Louis City*	IA Only
April 20, 1999	DR 1270	Severe Storms and Flooding	6	IA Only
May 12, 2000	DR 1328	Severe Thunderstorms and Flash Flooding	10	IA Only: 7 IA and PA: 3
February 6, 2002	DR 1403	Ice Storm	43	IA Only: 17 IA and PA: 26
May 6, 2002	DR 1412	Severe Storms and Tornadoes	79	IA Only: 9 PA Only: 31 IA and PA: 39
May 6, 2003	DR 1463	Severe Storms, Tornadoes, and Flooding	76	IA Only: 42 PA Only: 2 IA and PA: 32

Declaration Date	Disaster No.	Incident Type	No. of Counties Designated	Type of Assistance By County*
June 11, 2004	DR 1524	Severe Storms, Tornadoes, and Flooding	37	IA Only
March 16, 2006	DR 1631	Severe Storms, Tornadoes, and Flooding	41	IA Only: 12 PA Only: 4 IA and PA: 25
April 5, 2006	DR 1635	Severe Storms, Tornadoes, and Flooding	7	IA Only: 3 IA and PA: 4
November 2, 2006 ***	DR 1667	Severe Storms	St. Louis City*	PA Only
December 29, 2006	DR 1673	Severe Winter Storms	13 & St. Louis City*	PA Only
January 15, 2007	DR 1676	Severe Winter Storms and Flooding	38 & St. Louis City*	PA Only
June 11, 2007	DR 1708	Severe Storms and Flooding	30	IA Only: 6 PA Only: 12 IA and PA: 12
September 21, 2007	DR 1728	Severe Storms and Flooding	7	PA Only
December 27, 2007	DR 1736	Severe Winter Storms	42	PA Only
February 5, 2008	DR 1742	Severe Storms, Tornadoes, and Flooding	9	PA Only
March 12, 2008	DR 1748	Severe Winter Storms and Flooding	18	PA Only
March 19, 2008	DR 1749	Severe Storms and Flooding	56	IA Only: 5 PA Only: 21 IA and PA: 30
May 23, 2008	DR 1760	Severe Storms and Tornadoes	3	IA Only
June 25, 2008	DR 1773	Severe Storms and Flooding	53	IA Only: 3 PA Only: 26 IA and PA: 24
November 13, 2008	DR 1809	Severe Storms, Flooding, and a Tornado	56	IA Only: 7 PA Only: 26 IA and PA: 12
February 17, 2009	DR 1822	Severe Winter Storm	21	PA Only
June 19, 2009	DR 1847	Severe Storms, Tornadoes, and Flooding	52	PA Only: 24 IA Only: 4 IA and PA: 24
August 17, 2010	DR 1934	Severe Storms, Flooding, and Tornadoes	37	PA Only
March 23, 2011	DR 1961	Severe Winter Storm and Snow Storm	62	PA Only
April 22, 2011	DR 1980	Severe Storms, Tornadoes, and Flooding	38	PA Only: 13 IA and PA: 25
August 22, 2011	DR 4012	Severe Storms, Tornadoes, and Flooding	10	PA Only: 4 IA and PA: 6
Emergency Declarations				
March 12, 1979	EM 3071	Ice Jam, Flooding	2	PA Only
September 10, 2005	EM 3232	Hurricane Katrina Evacuation	114 & St. Louis City*	PA Only

Declaration Date	Disaster No.	Incident Type	No. of Counties Designated	Type of Assistance By County*
July 21, 2006	EM 3267	Severe Storms	7 & St. Louis City*	PA Only
December 12, 2007	EM 3281	Severe Winter Storms	Not available	PA Only
January 30, 2009	EM 3303	Severe Winter Storms	Not available	PA Only
Fire Management Assistance				
March 9, 2000	FMA 2292	Camden Fire Complex	N/A	N/A

Source: Federal Emergency Management Agency
Notes:
*IA denotes Individual Assistance; PA denotes Public Assistance
**Declaration was for incident in July 1998 and approved October 19, 1998, following state appeal
***Declaration was for incident in July 2006 and approved November 2, 2006

Figure 3.8 illustrates the declared disasters in Missouri, 1993 to 2013.

Figure 3.8-Declared Disasters 1993–2013

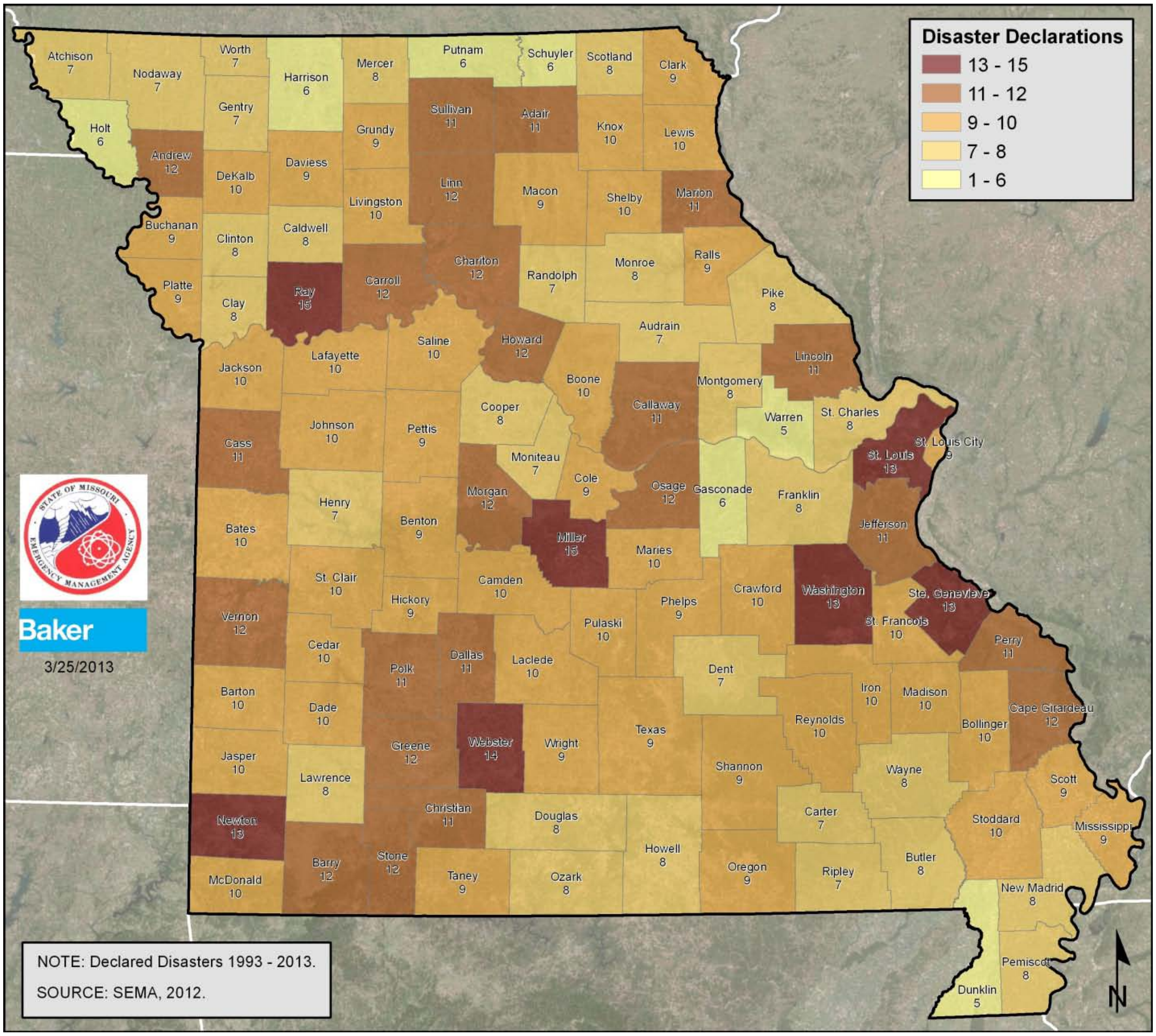


Table 3.1.3b shows the total amount of Public Assistance eligible for disaster declarations in Missouri from 1990 through 2013. Public Assistance includes state and federal assistance for uninsured losses to public property and infrastructure within those counties included in the disaster declaration.

Table 3.1.3b Public Assistance for Missouri Disasters, 1990–2013

Declaration Date	Disaster No.*	Number of Applicants	Damage Survey Reports/Project Worksheets	Total Amount Eligible
May 24, 1990	DR 867	72	2,023	$9,326,388
July 9, 1993	DR 995	743	14,479	$114,053,660
December 1, 1993	DR 1006	34	565	$3,194,267
June 2, 1995	DR 1054	253	2,275	$14,608,546
October 14, 1998	DR 1253	96	869	$8,528,288
March 15, 2000	FR 2292	1	Not available	$132,351
May 12, 2000	DR 1328	31	183	$3,359,091
February 6, 2002	DR 1403	247	654	$58,901,359
May 6, 2002	DR 1412	338	1679	$46,925,893
May 6, 2003	DR 1463	152	552	$26,062,440
September 10, 2005	EM 3232	12	22	$1,823,178
March 16, 2006	DR 1631	130	249	$7,295,763
April 5, 2006	DR 1635	28	110	$24,259,254
July 21, 2006	EM 3267	131	70	$14,733,715
November 2, 2006**	DR 1667	3	11	$876,083
December 29, 2006	DR 1673	144	273	$8,760,198
January 15, 2007	DR 1676	442	1122	$143,351,689
June 11, 2007	DR 1708	212	724	$10,064,209
September 21, 2007	DR 1728	19	301	$7,381,858
December 12, 2007	EM 3281	1	Not available	Not available
December 27, 2007	DR 1736	262	721	$33,496,284
February 5, 2008	DR 1742	44	99	$1,900,191
March 12, 2008	DR 1748	91	225	$13,745,285
March 19, 2008	DR 1749	307	2061	$35,005,581
June 25, 2008	DR 1773	315	1295	$36,778,059
November 13, 2008	DR 1809	169	472	$11,362,027
January 30, 2009	EM 3303	1	Not available	Not available
February 17, 2009	DR 1822	234	625	$202,556,199
June 19, 2009	DR 1847	209	670	$37,791,416
August 17, 2010	DR 1934^	265	Not available	$23,355,906
March 23, 2011	DR 1961^	609	Not available	$12,867,800

Declaration Date	Disaster No.*	Number of Applicants	Damage Survey Reports/Project Worksheets	Total Amount Eligible
April 22, 2011	DR 1980^	260	Not available	$276,562,753
August 22, 2011	DR 4012^	129	Not available	$37,971,836

Notes:*DR denotes disaster declaration, EM denotes emergency declaration, FS denotes Fire Suppression; **Declaration was for incident in July 2006 and approved November 2, 2006; ^ denotes disaster still open at time of plan update

Table 3.1.3c shows the total amount of Individual Assistance (IA) for IA-declared disasters in Missouri from 1990 through 2013. IA includes state and federal assistance to individuals and families for uninsured losses within those counties included in the disaster declaration. IA values are a sum of the combined Small Business Administration (SBA), Housing Assistance (HA), and Other Needs Assistance (ONA).

Table 3.1.3c Individual Assistance for Missouri Disasters, 1990–2013

Declaration Date	Disaster No.*	Individual Assistance	Number of Applicants
May 24, 1990	DR 867	$2,511,350	700
May 11, 1993	DR 989	$7,304,140	447
July 9, 1993	DR 995	$304,780,749	15,478
December 1,1993	DR 1006	$5,870,283	673
April 21, 1994	DR 1023	$7,483,860	779
June 2, 1995	DR 1054	$13,315,701	1,868
October 14, 1998	DR 1253	$7,421,547	1,623
October 19, 1998**	DR 1256	$4,946,171	1,763
April 20, 1999	DR 1270	$2,182,342	203
May 12, 2000	DR 1328	$9,795,522	515
February 6, 2002	DR 1403	$5,245,113	8,376
May 6, 2002	DR 1412	$9,560,924	6,834
May 6, 2003	DR 1463	$39,470,657	N/A
June 11, 2004	DR 1524	$4,063,315	1,209
March 16, 2006	DR 1631	$20,203,254	2,312
April 5, 2006	DR 1635	$13,517,496	152
June 11, 2007	DR 1708	$4,105,720	928
March 19, 2008	DR 1749	$24,943,335	6,067
May 23, 2008	DR 1760	$5,916,162	584
June 25, 2008	DR 1773	$10,601,444	2,081
November 13, 2008	DR 1809	$15,123,049	3,639
June 19, 2009	DR 1847	$8,175,414	3,113
April 22, 2011	DR 1980^	$90,347,077	16.489
August 22, 2011	DR 4012^	$8,207,147	862

Notes: *DR denotes disaster declaration; EM denotes emergency declaration; **Declaration was for incident in July 1998 and approved October 19, 1998; ^ denotes disaster still open at time of plan update

Table 3.1.3d shows the total projected federal expenditures through September 2006, for five major disasters including the Midwest Floods of 1993.

Table 3.1.3d United States Federal Disaster Expenditures-5 Major Disasters

Event	Date	Federal Expenditures (in Billions of Dollars)
Hurricane Andrew	August 1992	$3.9
Midwest Floods	Summer 1993	$6.0
Northridge Earthquake	January 1994	$3.7
Hurricane Katrina	August 2005	$150
Hurricane Rita	September 2005	$9.4

Source: United States Government Accountability Office, Report to Congressional Committees GAO;
*Numbers are in actual dollars, not adjusted for inflation

3.3 Profiling Hazards

Requirement §201.4(c)(2)(i):	[The state risk assessment shall include an overview of the] location of all natural hazards that can affect the state, including information on previous occurrences of hazard events, as well as the probability of future hazard events, using maps where appropriate.

This Hazard Analysis assesses various risks facing the State and its communities in order to evaluate and rank them. This process is then used to characterize hazards for emergency planning. It estimates the probability of occurrence and the severity of consequences for each hazard and provides a method of comparison. The evaluation involves many interrelated variables (toxicity, demographics, topography, etc.), and should be used by state officials in planning and prioritizing allocation of resources. It should be stressed that this Hazard Analysis was performed from a statewide perspective. Local jurisdictions should always perform their own hazard analysis and ranking during development and update of local mitigation plans.

A careful examination of hazard event profiles relevant to the Missouri study area serves to define historic hazard trends and provides a reference point for understanding the potential impacts from future predicted events. Reviewing historic data assists in evaluating hazard event profiles, which focus on answering the following questions: How often might a particular disaster occur?, Where are we most likely to be affected?, and How bad can it get?

The hazards covered in the analysis are listed in Table 3.1 and Table 3.2 along with the probability and severity ratings they were given in the State Hazard Analysis which have been validated by the State Risk Management Team (SRMT). As indicated previously, heat wave has now been profiled as extreme temperatures and associated cold temperature profiling was moved into this section from severe winter storm. The SRMT also agreed to add a new profile for cyber disruptions, as part of the manmade and other hazard section. The hazards listed are those that have been experienced by, or pose a potential threat to, Missourians. However, local or isolated problems that constitute potential disasters should not be overlooked. The ratings are situationally dependent.

Table 3.1. Natural Hazards Profiled in Mitigation Plan

Natural Hazards	Probability	Severity
Riverine Flooding (Major and Flash)	High	High
Dam Failure	Low	Moderate
Levee Failure 100-year Levees 500-year Levees	 High Moderate	 High High
Earthquakes	High	High
Land Subsidence/Sinkholes	High	Low
Severe Thunderstorms	High	Moderate
Tornadoes	High	High
Severe Winter Weather/Snow/Ice: North of MO River South of MO River	 High Low	 Moderate Moderate
Drought	Moderate	Moderate
Extreme Temperatures	Moderate	Moderate

Natural Hazards	Probability	Severity
Fires: Structural & Urban Wild	 High Moderate	 Moderate Low to Moderate

Table 3.2. Manmade and Other Hazards Profiled in Mitigation Plan

Manmade and Other Hazards	Probability	Severity
CBRNE Attack	Low	High
Civil Disorder	Low	Low to High
Cyber Disruption	Moderate to High	Moderate to High
Hazardous Materials Release: Fixed facility accidents Transportation accidents	 Moderate High	 Moderate Moderate
Mass Transportation Accidents	Moderate	Moderate
Nuclear Power Plants (Emergencies and Accidents)	Moderate	Moderate
Public Health Emergencies/Environmental Issues	High	Moderate to High
Special Events	Low	Low to High
Terrorism	Low	Low to High
Utilities (Interruptions and System Failures)	High	Low

Note: In regards to the local plans, local jurisdictions should not use the statewide probability ratings to determine their own hazard probabilities. Doing so could lead to incorrect assumptions.

The following definitions explain the probability and severity ratings for each hazard:

Probability—The likelihood that the hazard will occur.

- **Low**—The hazard has little or no chance of happening (Less than 1 percent chance of occurrence in any given year.).
- **Moderate**—The hazard has a reasonable probability of occurring (Between 1 and 10 percent chance of occurrence in any given year).
- **High**—The probability is considered sufficiently high to assume that the event will occur (Between 10 and 100 percent chance of occurrence in any given year).

Severity—The deaths, injuries, or damage (property or environmental) that could result from the hazard.

- **Low**—Few or minor damage or injuries are likely.
- **Moderate**—Injuries to personnel and damage to property and the environment is expected.
- **High**—Deaths and major injuries and damage will likely occur.

In the 2007 update, the State prioritized resources for the vulnerability assessment and estimating losses for the high probability and high severity hazards of earthquake, flooding, and tornadoes. This

undertaking included a major effort to quantify flood losses statewide using Hazus, as well as produce improved tornado and earthquake risk assessments.

For the 2010 Mitigation Plan update, the vulnerability assessment and loss estimates were expanded for all hazards addressed in the plan where sufficient data was available. In addition, the flood vulnerability assessment and loss estimates have been enhanced by integrating DFIRM depth grids into the Hazus flood loss scenarios where available.

As part of the 2013 Mitigation Plan update, all sections of the plan were updated. Specific focus was paid to the vulnerability assessments and loss estimations for both local jurisdictions and state owned and leased facilities. Greatly improved geospatial facility information, coupled with recently acquired LiDAR topographic data and DFIRM depth grids, contributed to this enhanced analysis, utilizing the latest GIS methodologies including the new version of Hazus 2.1. See Section 3.5 and Section 3.7 for details.

SEMA continually strives to improve the statewide risk assessment portion of this Plan, as an accurate risk assessment is vital to informing the development of a successful mitigation strategy. At the same time, it is also important as this information is oftentimes used as the starting point for many of the Local Hazard Mitigation Plans across the State. In the next Plan update, additional focus will be directed at enhancing the probability analysis methodology. In addition, SEMA will also revisit the vulnerability analysis methodology for all hazards to see if loss estimates can be better refined to arrive at specific damage estimates where possible. Current loss estimations for many of the hazards profiled in this section present exposure estimates. As with all information contained in the Plan document, the current vulnerability analysis was conducted utilizing the best information that was available at the time. Lastly, at the present time, information on past occurrences for many of the manmade hazards profiled in this Plan is either currently not readily available or is not able to be used in a public document. Future updates to this Plan will focus on trying to obtain more robust state-related hazard event information.

The National Oceanic and Atmospheric Administration's (NOAA) National Climatic Data Center (NCDC) is the source for many of the historical hazard events profiled in this Plan. While information contained in NCDC's Storm Events Database is generally the best, and sometimes the only, data available, the following disclaimer should still be noted.

Some information appearing in Storm Data may be provided by or gathered from sources outside the National Weather Service (NWS), such as the media, law enforcement and/or other government agencies, private companies, individuals, etc. An effort is made to use the best available information, but because of time and resource constraints, information from these sources may be unverified by the NWS. Accordingly, the NWS does not guarantee the accuracy or validity of the information.

Other data limitations to note include the following: data collecting for some hazards did not begin until 1993, damages reported are purely estimates based on the reporting entity, and damages reported are area-wide and not specific to the location.

The Emergency Management Accreditation Program (EMAP) is an independent non-profit organization, is a standard based voluntary assessment and peer review accreditation process for government programs responsible for coordinating prevention, mitigation, preparedness, response, and recovery activities for natural and human caused disasters. Accreditation is based on compliance with collaboratively developed national standards, the Emergency Management Standard by EMAP. As part

of the State of Missouri EMAP accreditation process, an analysis of the potential for detrimental impacts of hazards was conducted and integrated into the Plan. More detail on the state's accreditation process can be found on page 4.30 This information provides useful data to better asses risk and provide input for the development of mitigation strategies. This analysis was completed based on the EMAP Standard Published in September 2010. This document is available here. The results of the EMAP impact analysis are presented in each profile's discussion of impact. Additional information on EMAP can be found on Page 4.12.

Hazards are profiled below in groupings of similar hazards for ease of reference. The list below is not intended to represent hazard rankings. Natural hazards precede the manmade and other hazards.

3.3.1 Riverine Flooding (Major and Flash)

Description of Hazard

Floods are the number one weather-related killer in the United States. Figure 3.3.1.2, located later on in this section, depicts the number of declarations per county. Between 1990 and 2011, Missouri recorded more than 101 deaths[1] attributed to flooding. A flood is partial or complete inundation of normally dry land areas. Riverine flooding is defined as the overflow of rivers, streams, drains, and lakes due to excessive rainfall, rapid snowmelt, or ice. There are several types of riverine floods, including headwater, backwater, interior drainage, and flash flooding.

Figure 3.3.1.1 - May 2007 Flooding in Big Lake, Missouri

Photo courtesy of SEMA

Flash flooding is characterized by rapid accumulation or runoff of surface waters from any source. This type of flooding impacts smaller rivers, creeks, and streams and can occur as a result of dams being breached or overtopped. Because flash floods can develop in a matter of hours, most flood-related deaths result from this type of event.

The areas adjacent to rivers and stream banks that carry excess floodwater during rapid runoff are called floodplains. A floodplain is defined as the lowland and relatively flat area adjoining a river or stream. The terms "base flood" and "100-year flood" refer to the area in the floodplain that is subject to a one percent or greater chance of flooding in any given year, based on historical records. Floodplains are a vital part of a larger entity called a basin, which is defined as all the land drained by a river and its branches.

[1] Death total derived from updating the total from the 2009 total (90 deaths, per the 2010 HMP update) and adding the deaths for 2010 and 2011. No deaths in Missouri have been reported so far for 2012.

The land that forms the State of Missouri is contained within the Mississippi, Missouri, Arkansas, and White River Basins. The Mississippi River Basin drains the eastern part of the State, the Missouri River Basin drains most of the northern and central part of the State, the White River Basin drains the south-central part of the State, and the Arkansas River Basin drains the southwest part of the State. The Missouri River Basin drains over half the State. When the Missouri River joins the Mississippi River at St. Louis, it becomes part of the Mississippi River Basin, which is the largest basin in terms of volume of water drained on the North American continent.

In some cases, flooding may not be directly attributable to a river, stream, or lake overflowing its banks. Rather, it may simply be the combination of excessive rainfall or snowmelt, saturated ground, and inadequate drainage. With no place to go, the water will find the lowest elevations–areas that are often not in a floodplain. This type of flooding, often referred to as sheet flooding, is becoming increasingly prevalent as development outstrips the ability of the drainage infrastructure to properly carry and disburse the water flow. Flooding also occurs due to combined storm and sanitary sewers that cannot handle the tremendous flow of water that often accompanies storm events. Typically, the result is water backing into basements, which damages mechanical systems and can create serious public health and safety concerns.

Historical Statistics

Missouri has a long history of extensive flooding over the past century (see 0). Scores of river communities, including those along the Mississippi and Missouri rivers, have become quite skilled and experienced in flood-fighting efforts due to frequent instances of severe flooding in recent years. Flooding along Missouri's major rivers generally results in slow moving disasters. River crest levels are forecast several days in advance, allowing communities downstream sufficient time to take protective actions, such as sandbagging and evacuations. Nevertheless, these flood disasters exact a heavy toll in terms of human suffering and extensive losses to public and private property. By contrast, flash flood events in recent years have caused a higher number of deaths and major property damage in many areas of Missouri.

Table 3.3.1a Presidential Declarations for Missouri Floods Since 1975

Declaration Date	Disaster No.	Incident Type	Counties Declared	Type of Assistance*
July 21, 1976	DR 516	Severe Storms, Flooding	N/A**	
May 7, 1977	DR 535	Tornadoes, Flooding	Carroll, Clay, Lafayette, Ray, Cass, Jackson, Pettis	PA & IA
September 14, 1977	DR 538	Severe Storms, Flooding	N/A**	
March 12, 1979	EM 3071	Ice Jam, Flooding	N/A**	
April 21, 1979	DR 579	Tornadoes, Torrential Rain, Flooding	N/A**	
August 26, 1982	DR 667	Severe Storms, Flooding	N/A**	
December 10, 1982	DR 672	Severe Storms, Flooding	N/A**	

Declaration Date	Disaster No.	Incident Type	Counties Declared	Type of Assistance*
June 21, 1984	DR 713	Severe Storms, Flooding	N/A**	
October 14, 1986	DR 779	Severe Storms, Flooding	N/A**	
May 24, 1990	DR 867	Flooding, Severe Storm	N/A**	
May 11, 1993	DR 989	Severe Storm, Flooding	Jefferson, Lincoln, Marion, Pike, Ralls, St. Charles, St. Louis, Ste. Genevieve	IA
July 9, 1993	DR 995	Flooding, Severe Storm	Adair, Andrew, Atchison, Audrain, Barry, Barton, Bates, Benton, Boone, Buchanan, Caldwell, Callaway, Camden, Cape Girardeau, Carroll, Cass, Chariton, Christian, Clark, Clay, Clinton, Cole, Cooper, Crawford, Dade, Dallas, Daviess, DeKalb, Douglas, Franklin, Gasconade, Gentry, Greene, Grundy, Harrison, Henry, Hickory, Holt, Howard, Howell, Jackson, Jasper, Jefferson, Johnson, Knox, Laclede, Lafayette, Lawrence, Lewis, Lincoln, Linn, Livingston, Macon, Maries, Marion, McDonald, Mercer, Miller, Mississippi, Moniteau, Monroe, Montgomery, Morgan, New Madrid, Newton, Nodaway, Osage, Ozark, Pemiscot, Perry, Pettis, Phelps, Pike, Platte, Polk, Pulaski, Putnam, Ralls, Randolph, Ray, Saline, Schuyler, Scotland, Scott, Shelby, St. Charles, St. Clair, St. Francois, St. Louis, Ste. Genevieve, Stoddard, Stone, Sullivan, Taney, Texas, Vernon, Warren, Washington, Wayne, Webster, Worth, Wright, St. Louis City*	IA
			Adair, Andrew, Atchison, Barry, Barton, Bates, Benton, Boone, Buchanan, Caldwell, Callaway, Camden, Cape Girardeau, Carroll, Cass, Chariton, Christian, Clark, Clay, Clinton, Cole, Cooper, Crawford, Dade, Dallas, Daviess, DeKalb, Douglas, Franklin, Gasconade, Gentry, Greene, Grundy, Harrison, Henry, Holt, Howard, Jackson, Jefferson, Johnson, Knox, Laclede, Lafayette, Lawrence, Lewis, Lincoln, Linn, Livingston, Macon, Maries, Marion, McDonald, Mercer, Miller, Mississippi, Moniteau, Monroe, Montgomery, Morgan, New Madrid, Newton, Nodaway, Osage, Ozark, Pemiscot, Perry, Pettis, Pike, Platte, Polk, Pulaski, Putnam, Ralls, Ray, Saline, Schuyler, Scotland, Shelby, St. Charles, St. Clair, St. Louis, Ste. Genevieve, Stone, Sullivan, Texas, Warren, Worth, Wright, St. Louis City*	PA
December 1, 1993	DR 1006	Flooding, Severe Storm, Tornadoes	Bollinger, Butler, Cape Girardeau, Carter, Crawford, Dent, Franklin, Howell, Iron, Jefferson, Madison, Oregon, Perry, Pulaski, Reynolds, Ripley, Shannon, St. Francois, St. Louis, Ste. Genevieve, Stoddard, Texas, Washington, Wayne	IA

Declaration Date	Disaster No.	Incident Type	Counties Declared	Type of Assistance*
			Carter, Dent, Howell, Iron, Madison, Oregon, Perry, Reynolds, Shannon, St. Francois, Ste. Genevieve, Texas, Washington, Wayne	PA
April 21, 1994	DR 1023	Severe Storm, Flooding, Tornadoes	Barry, Callaway, Clay, Cole, Franklin, Jefferson, Lincoln, Morgan, Pemiscot, Phelps, Pulaski, Reynolds, Shannon, St. Charles, St. Louis, Vernon, Washington, St. Louis City*	IA
June 2, 1995	DR 1054	Severe Storm, Tornadoes, Hail, Flooding	Adair, Andrew, Atchison, Barry, Barton, Bates, Benton, Boone, Callaway, Camden, Cape Girardeau, Carroll, Cass, Chariton, Clark, Cole, Cooper, Dallas, Daviess, DeKalb, Franklin, Gasconade, Gentry, Henry, Howard, Jackson, Jasper, Jefferson, Johnson, Lafayette, Lewis, Lincoln, Linn, Macon, Maries, McDonald, Mercer, Miller, Mississippi, Moniteau, Montgomery, Morgan, New Madrid, Newton, Nodaway, Osage, Pemiscot, Perry, Ray, Saline, Scotland, Scott, St. Charles, St. Clair, St. Francois, St. Louis, Ste. Genevieve, Stone, Sullivan, Vernon, Warren, St. Louis City*	IA
			Andrew, Atchison, Barry, Bates, Benton, Boone, Callaway, Cape Girardeau, Carroll, Chariton, Clark, Cole, Cooper, Daviess, DeKalb, Franklin, Gasconade, Gentry, Henry, Howard, Jefferson, Johnson, Lafayette, Linn, Macon, McDonald, Mercer, Miller, Mississippi, Moniteau, Montgomery, Nodaway, Perry, Ray, Saline, St. Charles, St. Clair, St. Louis, Ste. Genevieve, Stone, Sullivan, Vernon, Warren	PA
October 14, 1998	DR 1253	Severe Storm and Flooding	Carroll, Clay, Jackson, Platte, Ray	IA
			Andrew, Barton, Caldwell, Carroll, Cedar, Chariton, Clay, Dade, DeKalb, Jackson, Linn, Livingston, Macon, Miller, Moniteau, Morgan, Platte, Polk, Ray	PA
Oct. 19, 1998**	DR 1256	Severe Storm and Flooding	Jackson, St. Louis, St. Louis City*	IA
April 20, 1999	DR 1270	Severe Storms and Flooding	Andrew, Cole, Iron, Macon, Madison, Osage	IA
May 12, 2000	DR 1328	Severe Thunderstorms and Flash Flooding	Crawford, Franklin, Jefferson, Gasconade, St. Charles, St. Francois, St. Louis, Ste. Genevieve, Warren, Washington	IA
			Franklin, Gasconade, Jefferson	PA

Declaration Date	Disaster No.	Incident Type	Counties Declared	Type of Assistance*
May 6, 2003	DR 1463	Severe Storms, Tornadoes, and Flooding	Barry, Barton, Bates, Benton, Bollinger, Buchanan, Camden, Cape, Cass, Cedar, Christian, Clay, Clinton, Cooper, Crawford, Dade, Dallas, Dent, Douglas, Franklin, Knox, Gasconade, Girardeau, Greene, Henry, Hickory, Iron, Jackson, Jasper, Jefferson, Johnson, Laclede, Lafayette, Lawrence, McDonald, Miller, Monroe, Morgan, Newton, Osage, Perry Pettis, Phelps, Platte, Polk, Pulaski, Ray, St. Francois, St. Louis, Ste. Genevieve, Saline, Scott, St. Clair, Stoddard, Stone, Taney, Vernon, Washington, Webster	IA
			Bollinger, Crawford, Franklin, Gasconade, Knox, Maries, Miller, Oregon, Osage, Pulaski, Washington	PA
June 11, 2004	DR 1524	Severe Storms, Tornadoes, and Flooding	Adair, Andrew, Bates, Benton, Caldwell, Carroll, Cass, Cedar, Chariton, Clay, Clinton, Daviess, DeKalb, Gentry, Grundy, Harrison, Henry, Hickory, Jackson, Johnson, Knox, Linn, Livingston, Macon, Mercer, Monroe, Nodaway, Platte, Polk, Randolph, Ray, Shelby, St. Clair, Sullivan, Vernon, Worth	IA
March 16, 2006	DR 1631	Severe Storms, Tornadoes, and Flooding	Bates, Benton, Boone, Carroll, Cass, Cedar, Christian, Cooper, Crawford, Greene, Henry, Hickory, Howard, Iron, Jefferson, Johnson, Lawrence, Lincoln, Mississippi, Monroe, Montgomery, Morgan, New Madrid, Newton, Perry, Pettis, Phelps, Putnam, Randolph, St. Clair, Ste. Genevieve, Scott, Saline, Taney, Vernon, Webster, Wright	IA
			Bates, Bollinger, Benton, Boone, Carroll, Cedar, Christian, Daviess, Greene, Henry, Hickory, Howard, Iron, Lawrence, Monroe, Montgomery, Morgan, Perry, Pettis, Putnam, Randolph, Ray, Saline, St. Clair, Vernon, Washington, Webster, Wright	PA
April 5, 2006	DR 1635	Severe Storms, Tornadoes, and Flooding	Andrew, Butler, Dunklin, Pemiscot, St. Francois, Stoddard	IA
			Andrew, Jefferson, Pemiscot, Pettis, St. Francois	PA
January 15, 2007	DR 1676	Severe Winter Storms and Flooding	Barry, Barton, Benton, Boone, Callaway, Camden, Cedar, Christian, Cole, Crawford, Dade, Dallas, Dent, Franklin, Gasconade, Greene, Hickory, Jasper, Laclede, Lawrence, Lincoln, Maries, McDonald, Miller, Montgomery, Newton, Osage, Phelps, Polk, Pulaski, St. Charles, St. Clair, St. Louis, Stone, Texas, Warren, Webster, Wright Counties, St. Louis City*	PA

Declaration Date	Disaster No.	Incident Type	Counties Declared	Type of Assistance*
June 11, 2007	DR-1708	Severe Storms and Flooding	Andrew, Atchison, Buchanan, Carroll, Chariton, Clay, Clinton, Daviess, DeKalb, Gentry, Holt, Jackson, Lafayette, Livingston, Morgan, Nodaway, Osage, and Platte Counties	IA
			Andrew, Atchison, Bates, Caldwell, Carroll, Cass, Chariton, Clinton, Daviess, Gentry, Grundy, Harrison, Holt, Howard, Lafayette, Linn, Livingston, Mercer, Nodaway, Platte, Ray, Saline, Sullivan and Worth Counties.	PA
September 21, 2007	DR-1728	Severe Storms and Flooding	Dade, Dallas, Greene, Laclede, Lawrence, Polk, and Webster Counties	PA
February 5, 2008	DR-1742	Severe Storms, Tornadoes, and Flooding	Barry, Dallas, Laclede, Maries, McDonald, Newton, Phelps, Stone, and Webster Counties	PA
March 12, 2008	DR-1748	Severe Winter Storms and Flooding	Bollinger, Butler, Cape Girardeau, Carter, Christian, Douglas, Greene, Madison, Mississippi, Ozark, Reynolds, Scott, Shannon, Stoddard, Texas, Wayne, Webster, and Wright	PA
March 19, 2009	DR-1749	Severe Storms and Flooding	Bollinger, Carter, Christian, Franklin, Greene, Iron, Jasper, Jefferson, Maries, Newton, Oregon, Phelps, Pulaski, Reynolds, St. Francois, Stone, Texas, Washington, and Wayne Counties	IA
			Audrain, Barry, Barton, Boone, Bollinger, Butler, Callaway, Camden, Cape Girardeau, Carter, Cedar, Christian, Cole, Cooper, Crawford, Dade, Dallas, Dent, Douglas, Dunklin, Franklin, Gasconade, Greene, Hickory, Howard, Howell, Iron, Jasper, Jefferson, Laclede, Lawrence, Lincoln, Madison, Maries, McDonald, Miller, Mississippi, Montgomery, Moniteau, Morgan, New Madrid, Newton, Oregon, Osage, Ozark, Pemiscot, Perry, Phelps, Pike, Polk, Pulaski, Reynolds, Ripley, St. Charles, St. Clair, St. Francois, St. Louis, Ste. Genevieve, Shannon, Scott, Stoddard, Stone, Taney, Texas, Vernon, Warren, Washington, Wayne, Webster, and Wright	PA
June 25, 2008	DR-1773	Severe Storms and Flooding	Adair, Andrew, Callaway, Cass, Chariton, Clark, Gentry, Greene, Harrison, Holt, Johnson, Lewis, Lincoln, Linn, Livingston, Macon, Marion, Monroe, Nodaway, Pike, Putnam, Ralls, St. Charles, Stone, Taney, Vernon, and Webster	IA

Declaration Date	Disaster No.	Incident Type	Counties Declared	Type of Assistance*
			Adair, Andrew, Atchison, Audrain, Bates, Callaway, Cape Girardeau, Carroll, Chariton, Clark, Christian, Daviess, Gentry, Grundy, Harrison, Howard, Holt, Knox, Lewis, Lincoln, Linn, Macon, Marion, Miller, Mississippi, Monroe, Morgan, Nodaway, Perry, Pettis, Pike, Putnam, Ralls, Ray, Shelby, St. Charles, Stone, Sullivan, Taney, and Vernon Counties for Public Assistance. Also, the counties of Buchanan, Jefferson, Pemiscot, Platte, New Madrid, Scott, St. Louis, and the independent City of St. Louis for Category B Public Assistance	PA
November 13, 2008	DR-1809	Severe Storms, Flooding, and a Tornado	Boone, Callaway, Chariton, Howell, Jefferson, Lewis, Lincoln, Linn, Marion, Montgomery, Osage, Schuyler, St. Charles, St. Louis, Stone, Taney, Texas, and Webster Counties and the Independent City of St. Louis	IA
			Adair, Audrain, Barry, Bollinger, Butler, Callaway, Cape Girardeau, Carter, Chariton, Christian, Clark, Crawford, Dent, Douglas, Dunklin, Howard, Howell, Knox, Lewis, Lincoln, Linn, Madison, Maries, Marion, Miller, Mississippi, New Madrid, Oregon, Ozark, Perry, Ralls, Randolph, Ray, Reynolds, Ripley, Schuyler, Scotland, Scott, Shannon, Shelby, St. Genevieve, Stoddard, Stone, Sullivan, Taney, Texas, Wayne, Webster, and Wright	PA
June 19, 2009	DR-1847	Severe Storms, Tornadoes, and Flooding	Adair, Barry, Barton, Bollinger, Cape Girardeau, Christian, Dade, Dallas, Dent, Douglas, Greene, Howell, Iron, Jasper, Jefferson, Laclede, Lawrence, Madison, Newton, Ozark, Polk, Reynolds, Ripley, St. Francois, Shannon, Texas, Washington, Webster	IA
			Adair, Barton, Bollinger, Camden, Cape Girardeau, Cedar, Crawford, Dade, Dallas, Dent, Douglas, Greene, Hickory, Howell, Iron, Jasper, Knox, Laclede, Lewis, Madison, Maries, Marion, Miller, Newton, Oregon, Ozark, Perry, Phelps, Polk, Pulaski, Ray, Reynolds, Ripley, St. Francois, Ste. Genevieve, Saline, Shannon, Shelby, Stone, Sullivan, Texas, Vernon, Washington, Wayne, Webster, Wright	PA

Declaration Date	Disaster No.	Incident Type	Counties Declared	Type of Assistance*
August 17, 2010	DR-1934	Severe Storms, Flooding, and Tornadoes	Adair County, Andrew County, Atchison County, Buchanan County, Caldwell County, Carroll County, Cass County, Chariton County, Clark County, Clinton County, Daviess County, DeKalb County, Gentry County, Grundy County, Harrison County, Holt County, Howard County, Jackson County, Knox County, Lafayette County, Lewis County, Linn County, Livingston County, Marion County, Mercer County, Monroe County, Nodaway County, Perry County, Pike County, Putnam County, Ralls County, Ray County, Schuyler County, Scotland County, Shelby County, Sullivan County and Worth County.	PA
May 9, 2011	DR-1980	Severe Storms, Tornadoes, and Flooding	Bollinger County, Butler County, Cape Girardeau County, Carter County, Dunklin County, Howell County, Jasper County, Lawrence County, McDonald County, Mississippi County, New Madrid County, Newton County, Pemiscot County, Pettis County, Phelps County, Pulaski County, Reynolds County, Ripley County, Saint Francois County, Saint Louis County, Scott County, Stoddard County, Stone County, Taney County and Wayne County.	IA
			Barry County, Bollinger County, Butler County, Cape Girardeau County, Carter County, Christian County, Douglas County, Dunklin County, Howell County, Iron County, Jasper County, Madison County, McDonald County, Miller County, Mississippi County, New Madrid County, Newton County, Oregon County, Ozark County, Pemiscot County, Perry County, Pettis County, Polk County, Reynolds County, Ripley County, Saint Francois County, Saint Louis County, Sainte Genevieve County, Scott County, Shannon County, Stoddard County, Stone County, Taney County, Texas County, Washington County, Wayne County, Webster County and Wright County	PA
August 12, 2011	DR-4012	Flooding	Andrew County, Atchison County, Buchanan County, Holt County, Lafayette County and Platte County.	IA
			Andrew County, Atchison County, Buchanan County, Carroll County, Cooper County, Holt County, Howard County, Lafayette County, Platte County, Ray County and Saline County.	PA

Source: Federal Emergency Management Agency, State Emergency Management Agency
Note:
*IA denotes Individual Assistance; PA denotes Public Assistance
** Source information was not available on FEMA website

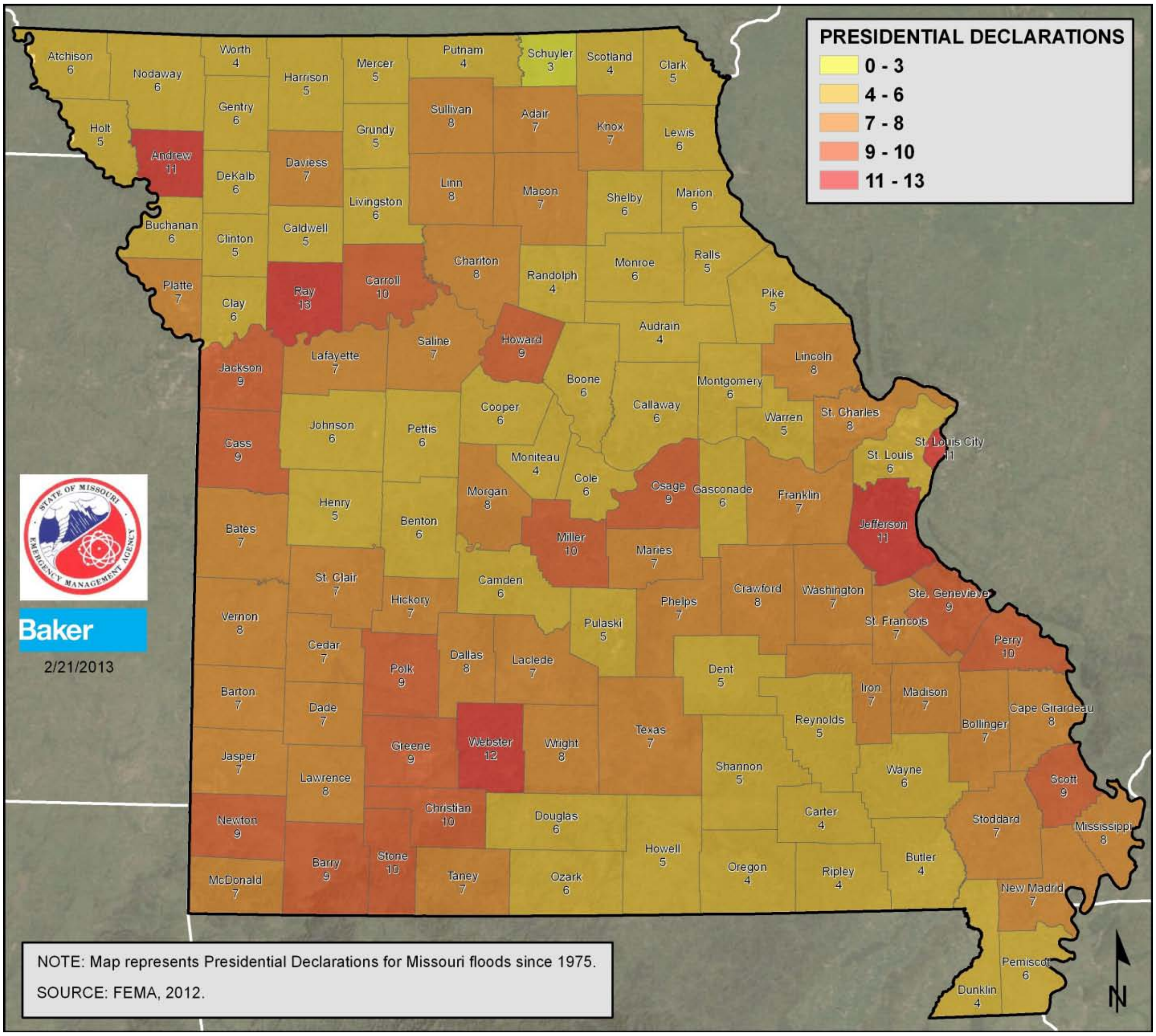
Ranking among the State's most notable flood disasters are the Missouri River flood of 1927, which spread destruction across 17 million acres, and the flood of 1951, which caused an estimated $400 million[2] in damage. Record flooding also occurred in 1973 along the Mississippi River, where backwater inundated 474,000 acres at a loss of $40 million[3]. The unseasonably heavy rainfall produced severe headwater flooding along many of the area's tributary streams, particularly in the St. John's Basin in Missouri and along the St. Francis and White Rivers in Arkansas. Of special historic interest is the December 1982 flood that spread dioxin-contaminated soil in the Times Beach area near St. Louis and led to a federal buyout of the entire town. In the fall of 1986, record flooding returned in Missouri, as well as in Michigan, Illinois, Kansas, and Oklahoma, with all these states declared federal disaster areas. Significant flooding next occurred in the State in the spring of 1990, particularly along the Missouri River in western, central, and portions of eastern Missouri. Record-level, repetitive flooding occurred from 1993 through 1995, and flash flooding ravaged several areas of the State in July and October 1998. In the springs of 1999 and 2000, flash flooding and severe storms again battered portions of the State. The most recent significant flooding event occurred in the spring of 2011, the Birds Point-New Madrid Area Flood, in which the levees were intentionally blown in order to relieve flood waters downstream[4].

Declarations in Missouri

The State of Missouri has had more than 35 flood related disaster declarations since 1976, of which, nearly all the counties within the state have been affected to some degree. Certain parts of the state have been minimally affected by flooding, i.e. Carter County (4 declarations) and Oregon County (4 declarations). Other parts have been moderately affected, i.e. Washington County (7 declarations) and Jasper County (7 declarations). Furthermore, some parts have been heavily affected by flooding, i.e. Jefferson County (11 declarations) and Ray county (13 declarations). The figure below helps to identify the parts of the state where counties have many declarations and as such a high risk of repeated flooding.

[2] Not adjusted for inflation
[3] Not adjusted for inflation
[4] The Bootheel Regional Planning and Economic Development Commission "The Historic Flood of 2011"

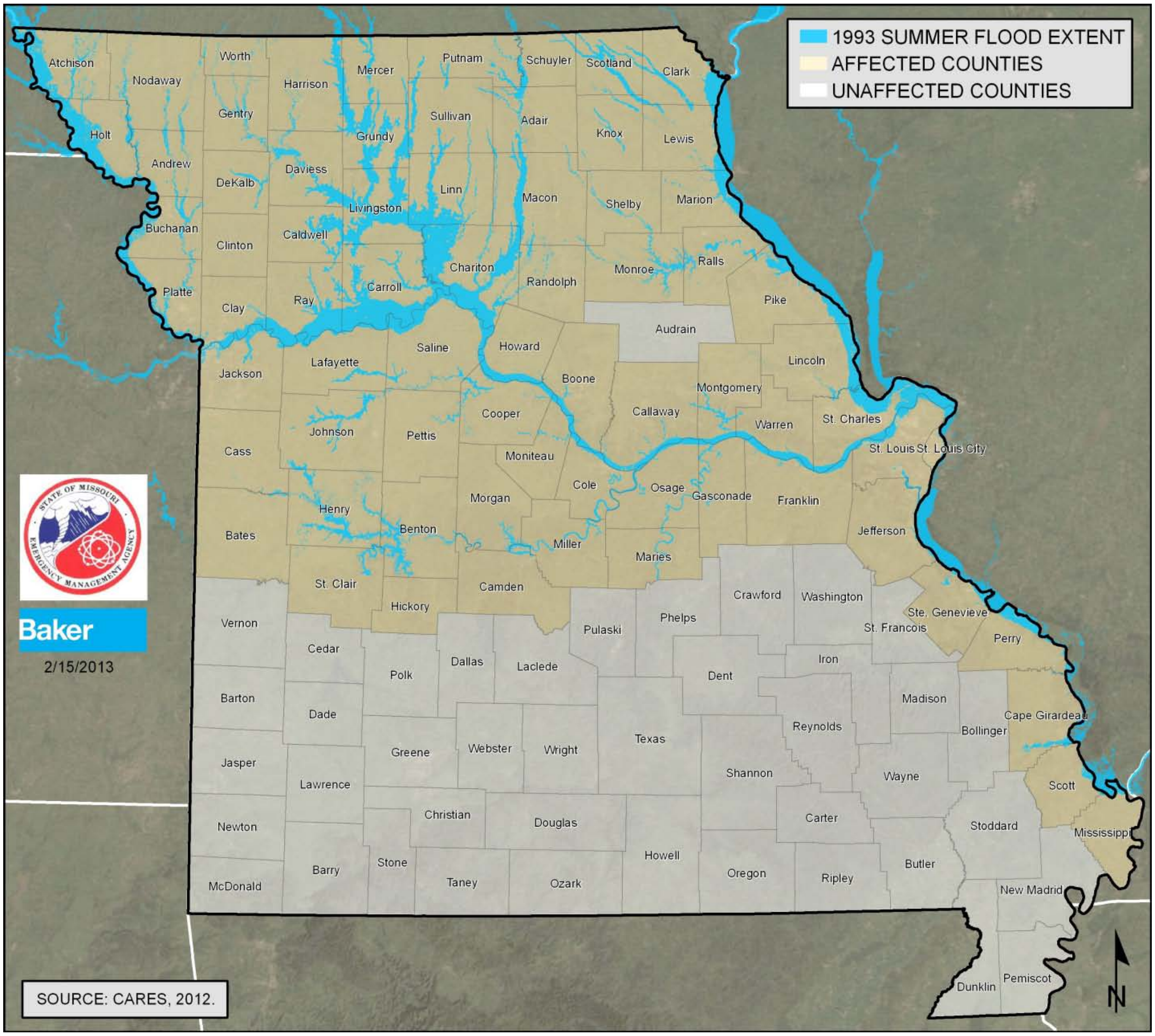
Figure 3.3.1.2 - Number of Presidential Declarations by County



Flooding Across the State

While most of the flooding has been related to the Missouri River to some extent this is not always the case. The following figure depicts the 1% chance flood boundaries throughout the state during the 1993 floods. Some areas have more detail due to studies done on those watersheds. By comparing this figure to the previous figure, showing the number of disaster declarations per county, one could form a clearer understanding of the flooding risk and potential for repetitive loss within the state.

Figure 3.3.1.3 - Flooding Extent during the 1993 Floods



Floods of 1993–1995[5,6]

The floods of 1993 through 1995 represent Missouri's worst repetitive flood events. Within this time frame, there were five presidential disaster declarations, including four in just one 12-month period. This period extended from May 11, 1993, when the first declaration was issued by President Clinton, through April 21, 1994, when the fourth declaration was approved. Flooding in the spring of 1995 resulted in a fifth disaster declaration, issued on June 2, 1995.

[5] SEMA. "The Response, Recovery and Lessons Learned from the Missouri Floods of 1993 and 1994."

[6] State Emergency Management Agency (SEMA). "After Action Report. The 1995 Missouri Flood."

The ravages of these floods left a legacy of destruction, human suffering, and property damage of unprecedented terms in Missouri history. It took the state and many communities several years to recover from the damage.

In 1993 alone, 112 of Missouri's 114 counties received one or more disaster declarations. Only Cedar County in southwest Missouri and Dunklin County in the southeast portion of the State were not included in any of the 1993 declarations.

A number of flood-level records were broken in 1993. In the USACE St. Louis and Kansas City Districts, 867 of 947 federal and nonfederal levees failed or were overtopped, greatly contributing to the flooding. The Missouri River, normally no more than a half-mile wide, expanded to 5-6 miles wide north of St. Joseph and 8-10 miles wide east of Kansas City. Just north of St. Louis, the River reached 20 miles wide near its confluence with the Mississippi. Almost half of the 620 square miles of St. Charles County were underwater. Table 3.3.1b and Table 3.3.1c highlight high-water stages and levee failures that resulted from the summer flood of 1993.

Table 3.3.1b Record High-Water Stages in Missouri During the Summer 1993 Flood (in feet)

Community	1993 Level	Previous Record	Flood Stage
Mississippi River			
Hannibal	31.8	28.6	16
St. Louis	49.4	43.3	30
Cape Girardeau	48.0	45.6	32
Missouri River			
St. Joseph	32.7	26.8	17
Kansas City	48.9	46.2	32
Jefferson City	38.6	34.2	23
Hermann	36.3	35.8	21
St. Charles	39.5	37.5	25

Source: U.S. Army Corps of Engineers (1993) as referenced in the 2010 Missouri Hazard Mitigation Plan.

Table 3.3.1c Distribution of Levee Failures by USACE District/Number of Failed or Overtopped Levees, Summer 1993 Flood

Corps of Engineers District	Federal Levees	Non-federal Levees
St. Louis*	12 of 42	39 of 47
Kansas City**	6 of 48	810 of 810
Total Levees	18 of 90	849 of 857

Source: Natural Disaster Survey Report, "The Great Flood of '93."

Notes: The difference in the failure rates above is because most federal levees are designed to withstand a 100- to 500-year flood, while non-federal levees, predominantly protecting agricultural lands, are frequently designed for a flood with a return period of 50 years or less.

*Includes eastern Missouri and portions of Illinois

**Includes northwestern, west-central, and portions of southwest Missouri and areas in Kansas and Nebraska

Floods of 1998 [7]

Severe flash flooding in the summer and fall of 1998 took a heavy toll in terms of lives lost and extensive property damage in several areas of the State. In all, at least 17 people died as a result of the two flood events. Almost all of the casualties occurred when people attempted to drive their vehicles through rushing water, overturned their vehicle into floodwaters, or were trapped and swept off a flooded bridge. Both flood incidents ultimately resulted in presidential disaster declarations to provide state and federal assistance in the declared counties.

Spring 1999 and 2000 Floods [8]

On April 3, 1999, a heavy rainstorm in southeast Missouri caused severe flash flooding in Madison County, including the communities of Fredericktown and Marquand. One death (due to electrocution) was attributed to that flood event when 7 to 10 inches of rain fell over a two-hour period, causing the St. Francois River to crest at twice the height of flood stage. More than 400 homes were adversely affected, with nearly half receiving significant water damage within the living spaces. Seven businesses were damaged, and five were determined to be destroyed. On April 20, 1999, a presidential disaster declaration for individual assistance (DR 1270) was approved for Madison County and five additional counties (Andrew, Cole, Osage, Iron, and Macon) were later approved by FEMA as add-ons to that declaration as a result of subsequent tornadoes and storms. More than 30 Missouri counties were also designated as eligible for disaster relief for agricultural losses suffered from the April storms.

For two consecutive spring seasons, Missouri experienced devastating flash flooding that forced hundreds of people from their homes and caused millions of dollars in property damage to both homes and businesses. Although the flash flooding in both events was confined to a few areas, the type of devastation was equal or greater than some of Missouri's worst river flooding events. On May 6 and 7, 2000, a slow-moving storm unleashed 15 inches of rain in Franklin and Jefferson counties in less than 24 hours. The city of Union in Franklin County was among the hardest hit due to extreme flooding from Flat Creek. In all, 10 counties were included in a presidential disaster declaration (DR 1328) issued on May 12, 2000. Three counties were declared eligible for Public Assistance and Individual Assistance, and seven others were declared for Individual Assistance.

[7] http://www.fema.gov/disasters/grid/state/67?field_disaster_type_term_tid_1=All

[8] http://www.fema.gov/disasters/grid/state/67?field_disaster_type_term_tid_1=All

Spring 2003 Flood [9]

Flash flooding occurred on May 7 and 8, 2003, and became a major flooding event across all of southern and central Missouri through the early afternoon of May 9. In addition to the numerous road closures; bridges blocked by debris; evacuations of towns, campgrounds, and parks; and moderate river flooding, many communities had their worst flooding in more than 10 years. In Howell County, the most significant damage occurred after the Warm Fork River washed out a portion of train track four miles southeast of West Plains, resulting in a train derailment. Four locomotives, each weighing 260,000 pounds, and 10 railroad cars were knocked off the tracks pouring out diesel fuel. In addition to all of the flash flooding reports, river flooding became significant as all of the southern Missouri rivers rose above flood stage by the middle of May. Some of the rivers crested at levels equivalent to the 1993 flood event.

Flood of 2004 [10]

The month of May 2004 saw severe storms containing heavy rains and large hail. A strong storm moved through the State from west to east, roughly along the Interstate 70 corridor, during the night of May 18–19, 2004. The most severe hit area appeared to be in Cass County south of Kansas City. Twenty-two homes were evacuated in Freeman and Lake Annett in Cass County as a result of major flash flooding.

Spring 2006 Flood [11]

A series of severe weather systems pushed across Missouri in March and April. These storms produced a variety of damaging elements which included high winds, tornados, flooding and heavy snow. Forty-nine Missouri counties received Federal Major Disaster Declarations. Through June 14, 2006, homeowners, renters and business owners who were affected by the severe storms, tornadoes and flooding of March 8-13 and March 30 - April 3, 2006, had been approved to receive more than $32,605,969 million in assistance from FEMA, the U.S. Small Business Administration (SBA) and the SEMA.

Floods of 2007 [12]

On January 12-14, a series of severe winter storms swept across Missouri causing heavy damage throughout the State from rain, freezing rain and flooding. An area from Joplin to St. Louis along the I-44 corridor was the heaviest hit. More winter weather came through much of the State on January 20, bringing 4-6" inches of snow in some areas and additional minor ice accumulations. Hundreds of thousands were without power to their homes resulting in 119 shelters being opened across the State.

During the weekend of May 4-7, 2007, a strong upper level storm system generated numerous rounds of heavy rainfall across the Midwest. Even though in the record books the May 2007 floods will not go down as the worst flooding ever experienced in the Midwest, in many locations May 2007 flooding was in the top three events of all time. More significantly, two cities experienced the all-time record flood levels at their locations. The Tarkio River near the city of Fairfax, MO experienced a record high river crest of 25.78 ft. recorded Monday, May 7th. This river stage broke the previous record of 25.60 ft. set on July 23, 1993. The second location to experience record flooding was near the city of Napolean, MO. At Napolean, the Missouri River reached a record level of 28.86 ft., eclipsing the previous record of 27.40 ft. set back on May 19, 1995. The Association of Missouri Electric Cooperatives reported that a cooperative in Holt County had an estimated $159,000 in damages as a result of this event.

[9] http://www.fema.gov/disasters/grid/state/67?field_disaster_type_term_tid_1=All
[10] http://www.fema.gov/disasters/grid/state/67?field_disaster_type_term_tid_1=All
[11] http://www.fema.gov/disasters/grid/state/67?field_disaster_type_term_tid_1=All
[12] http://www.fema.gov/disasters/grid/state/67?field_disaster_type_term_tid_1=All

Heavy rainfall and flash flooding occurred over the Missouri Ozarks and southeast Kansas from the 19th to the 20th of August 2007. The heavy rain was a result of the remnant energy from tropical system "Erin" as it interacted with high levels of moisture in the atmosphere. The heaviest rainfall occurred in a band that affected northern Lawrence, Eastern Dade, northern Greene and southern Polk counties, where 10 to 12 inches of rainfall occurred. Tropical moisture, high radar reflectivities and slow movement to the storms led to the powerful flash flooding which damaged roadways and bridges and caused one death in Laclede County.

Floods of 2008[13]

An unusually early severe weather outbreak hit the Missouri Ozarks Monday afternoon, January 7th, into the early morning hours Tuesday, January 8th, 2008. Numerous supercell thunderstorms spawned at least 33 tornadoes that resulted in significant damage to homes, trees and power lines. The supercell thunderstorms were followed by a violent squall line that produced damaging straight line winds in excess of 70 mph. In addition, the storms produced torrential rainfall and flash flooding. The storms developed as an intense storm system tracked out of the Rockies and interacted with an unseasonably warm, moist and unstable airmass across the Ozarks.

February 2008

This event was primarily a winter storm disaster with large amounts of snow. However, due to the large amounts of rain and ice buildup that accompanied the storm, flooding was included in the declaration request. For additional information on this event, see the Winter Storm Section 3.3.10 under FEMA-1748-DR.

An intensifying wave of low pressure developed on March 17, 2008 in the Texas panhandle, and headed to the lower Midwest. This system tapped into abundant Gulf moisture and combined with a strong upper level jet and a warm, unstable atmosphere to produce extremely heavy rain from southwestern Missouri eastward into southern Indiana over the next three days. The first area it affected was southwestern Missouri, which received most of the heavy rain on March 17th and early on March 18th. Much of the region received four to six inches of rain, with isolated areas had10 inches or more. By the morning of March 18th the surface low pressure system was located near St. Louis, and heavy rain was falling from the central Ozarks into southern Illinois and Indiana. The NWS cooperative observer located in Cape Girardeau, MO reported 13.84 inches for the 48-hour period from the morning of March 18 to the morning of March 20th. The Cape Girardeau Regional Airport reported 11.49 inches for just the 18th alone. Preliminary measurements indicate that 17.83 inches of rain fell at Cape Girardeau in March 2008. This breaks the previous ***all-time*** monthly record at Cape Girardeau of 16.89 inches, set in May of 1973, and as well as the March record rainfall of 11.89 inches sent in 1977. Five Missourians died as a result of these storms–two in Greene County, one in Reynolds County, one in Bollinger County and one in Lawrence County. At one point during the event, the Missouri Department of Transportation reported 190 locations on state roads that were closed due to flooding. A few of those locations would remain closed through August as the year of 2008 continued to set record levels of rainfall in Missouri and the Midwest. Nine cooperatives in the Association of Missouri Electric Cooperatives reported total estimated damages in the amount of $885,800 as a result of this event. In all, 17 counties were included in Presidential Disaster Declaration FEMA-1749-DR, for individual assistance issued on March 19, 2008. Another 78 counties were declared eligible for public assistance.

[13] http://www.fema.gov/disasters/grid/state/67?field_disaster_type_term_tid_1=All

The period February through April 2008 was the wettest on record for the Midwest region, with an average 11.64 inches of precipitation. This was also the wettest February-April for Missouri with 18.92 inches. The wet weather pattern over the southern Midwest in February and March continued into the first half of April. On April 3rd and April 4th two to four inches of rain fell from the Missouri Ozarks into western Kentucky, southern Illinois, and southern Indiana, with isolated amounts in excess of 6.50 inches. The heavy rain caused another round of flash flooding and road closures in these areas, and exacerbated flooding already in progress on rivers and streams. On April 8-10 another strong spring storm moved through the Midwest on a more northerly track. This storm dropped another 3 to 4 inches of rain on southwestern Missouri, and one to three inches of rain in a band from northwestern Missouri into southeastern Iowa.

June of 2008 was a very wet month across a significant portion of the Midwest. Precipitation was more than 200 percent of normal across much of Missouri. The wet first half of the year, along with the record June rainfall caused devastating flooding and numerous flash floods in Missouri. This resulted in record flooding on parts of the Mississippi River. This flooding exceeded levels reached during the Great Flood of 1993 in some locations. Springfield, MO received 3.88 inches in a day, breaking the old record for the date of 2.00 daily inches set in 2004. The flash flooding of Galloway Creek in Springfield significantly damaged Galloway Village, a historic section of specialty and antique shops. Water levels reached three feet in just an hour. Flood waters also washed away tons of rock from the railroad line to the James River Power Plant, interrupting coal shipments until workers could finish replacing the rock several days later. Along the Mississippi, many levees were dealing with structural failure possibilities even without overtopping. More rain caused already weakened levees to give way. Several cities were wholly or partially flooded by levee failures or overtopping, including Clarksville, Winfield, Foley, and St. Charles. The Winfield failure was especially illustrative of the fragility of some levees, as the flood waters broke through a 3 inch tunnel dug by a muskrat and water poured out under pressure like a fire hose. Many volunteers and National Guard troops were able to keep most of the levees intact. Three cooperatives in the Association of Missouri Electric Cooperatives reported total estimated damages of $142,000 as a result of this event. Presidential Disaster Declaration FEMA-1773-DR, (see Table 3.3.15a) issued on June 25, 2008, included 27 counties for individual assistance and 72 counties eligible for public assistance.

July 2009

An early July low pressure developed along the front in the southern Plains and moved along the front, setting off thunderstorms from Missouri through Ohio. Late on July 2, 2009 two to six inches of rain fell in western Missouri northwest of Kansas City. The rain caused flash flooding in Parkville, MO. The lower levels of 20 homes were flooded in one subdivision when debris blocked drainage tubes at a bridge. In central Missouri, three to four inches of rain fell in Moniteau, Cole, and Osage counties. The week of July 24th brought extremely heavy rains to previously saturated portions of Missouri. Rainfall exceeded 12 inches in portions of northern Missouri, and amounts from 3 to 6 inches were reported from southern Iowa to just north of St. Louis, resulting in flash flood watches and warnings for much of the region. The largest 24-hour rainfall amount reported was 14.95 inches one mile west of Brunswick, MO. A dam on a 2-acre pond at a country club near Kirksville was breached and water was flooding a major highway. Two men were rescued from a tree after their vehicle was swept off of a road by floodwaters in Ralls County, and authorities reported numerous vehicle rescues. The next round of heavy rain came on July 29-30 as the remnants of Hurricane Dolly entered the Midwest. Heavy rain fell from north of Kansas City, MO across north-central Missouri, preventing any recovery from the flooding caused by the previous two systems. In Platte City, MO, 7.70 inches of rain was recorded into the 24 hour period ending at 7:00 a.m. on July 30, and there were numerous reports of 2 to 3 inches of rain in northwestern Missouri. The heavy rain closed many roads and kept rivers and streams in flood. Three cooperatives in

the Association of Missouri Electric Cooperatives reported a total estimated $190,000 in damages as a result of this event. In the wake of the week of heavy rain in Missouri, Mark Twain Lake, a flood control reservoir and major recreational destination, reached a record level of 640.36 feet on July 30, swelling it to twice its normal size. The previous record was 636.77 feet in 1993. On July 30 USACE closed the lake to all boating traffic, and increased the water released through the dam into the Salt River to 50,000 cubic feet per second (cfs). Releases above 12,000 cfs were unprecedented. Authorities also closed the Salt River to recreational boating traffic from the Clarence Cannon Dam to the Mississippi River because of flooding. This had a serious impact on area businesses during the height of the tourist season.

Two tropical systems, Gustav and Ike, brought heavy rain to the central Midwest during the first half of September. Many locations from Missouri through Illinois into southern Michigan received two to three times normal September rainfall, and much of that rain fell the first two weeks of the month. A number of locations set monthly records for precipitation. The heaviest rains occurred across the northern half of the State. In northeast Missouri, Kirksville received a total of 8.14 inches of rain, while in Columbia 7.19 inches of rain from the remnants of Hurricane Ike were reported. The St. Louis area was also hard hit, with O'Fallon reporting 5.84 inches of rain. Three deaths were reported in association with the storm. A woman was killed when a tree was struck by lightning and a limb fell on her in Ladue. Two other people were killed in University City when they were swept away by flood waters while trying to move their vehicles to higher ground. Numerous roads were closed by flooding, including a stretch of Interstate 70. At the peak of the storm nearly 106,000 people were without power in the St. Louis Area.

***Spring 2009*[14]**

A wide swath of severe weather tore across Missouri on May 8, 2009. The fast moving complex of severe thunderstorms brought damaging winds, large hail and tornadoes to southern Missouri and Illinois. Thousands of trees were uprooted, numerous buildings and homes sustained damage from wind and hail. In addition, three to locally five inches of rainfall caused extensive flash flooding from Crawford County, Missouri to Randolph County, Illinois. Rainfall totals across the southern half of the State reached 200 percent of normal for the first week of the month. Two weather systems tracked across northern Missouri May 12th through the 16th. The heavy rainfall pushed some locations in the State to rainfall totals exceeding 300 percent of normal. Flash flood warnings blanketed the affected areas as storms dumped their rain on saturated ground. Roads were closed due to flooding in many rural and urban areas.

***Spring 2010*[15]**

On July 27, 2010, a major disaster declaration was requested due to severe storms, flooding, and tornadoes during the period of June 12 to July 31, 2010. The Governor requested a declaration for Individual Assistance for 11 counties and Public Assistance for 29 counties and Hazard Mitigation for the entire State of Missouri. During the period of July 7 – 20, 2010, joint Federal, State, and local Preliminary Damage Assessments (PDAs) were conducted in the requested counties and are summarized below. PDAs estimate damages immediately after an event and are considered, along with several other factors, in determining whether a disaster is of such severity and magnitude that effective response is beyond the capabilities of the State and the affected local governments, and that Federal assistance is necessary.

[14] http://www.fema.gov/pdf/news/pda/1847.pdf
[15] http://www.fema.gov/pdf/news/pda/1934.pdf

On August 17, 2010, the President declared that a major disaster exists in the State of Missouri. This declaration made Public Assistance requested by the Governor available to State and eligible local governments and certain private nonprofit organizations on a cost-sharing basis for emergency work and the repair or replacement of facilities damaged by the severe storms, flooding, and tornadoes in Adair, Andrew, Atchison, Buchanan, Caldwell, Carroll, Cass, Chariton, Clark, Clinton, Daviess, DeKalb, Gentry, Grundy, Harrison, Holt, Howard, Jackson, Lafayette, Lewis, Livingston, Mercer, Nodaway, Putnam, Ray, Schuyler, Scotland, Sullivan, and Worth Counties. This declaration also made Hazard Mitigation Grant Program assistance requested by the Governor available for hazard mitigation measures statewide.

Spring 2011[16]

On May 5, 2011, a major disaster declaration was requested due to severe storms, tornadoes, and flooding beginning on April 19, 2011, and continuing. The Governor requested a declaration for Individual Assistance for 29 counties, Public Assistance for 38 counties, and Hazard Mitigation statewide. The Governor further requested direct Federal assistance. During the period of April 27 to May 5, 2011, joint Federal, State, and local Preliminary Damage Assessments (PDAs) were conducted in the requested counties and are summarized below. PDAs estimate damages immediately after an event and are considered, along with several other factors, in determining whether a disaster is of such severity and magnitude that effective response is beyond the capabilities of the State and the affected local governments, and that Federal assistance is necessary.

On May 9, 2011, the President declared that a major disaster exists in the State of Missouri. This declaration made Individual Assistance requested by the Governor available to affected individuals and households in Butler, Mississippi, New Madrid, St. Louis, and Taney Counties. This declaration also made Public Assistance, including direct Federal assistance requested by the Governor available to State and eligible local governments and certain private nonprofit organizations on a cost-sharing basis in St. Louis County. Finally, this declaration made Hazard Mitigation Grant Program assistance requested by the Governor available for hazard mitigation measures statewide.

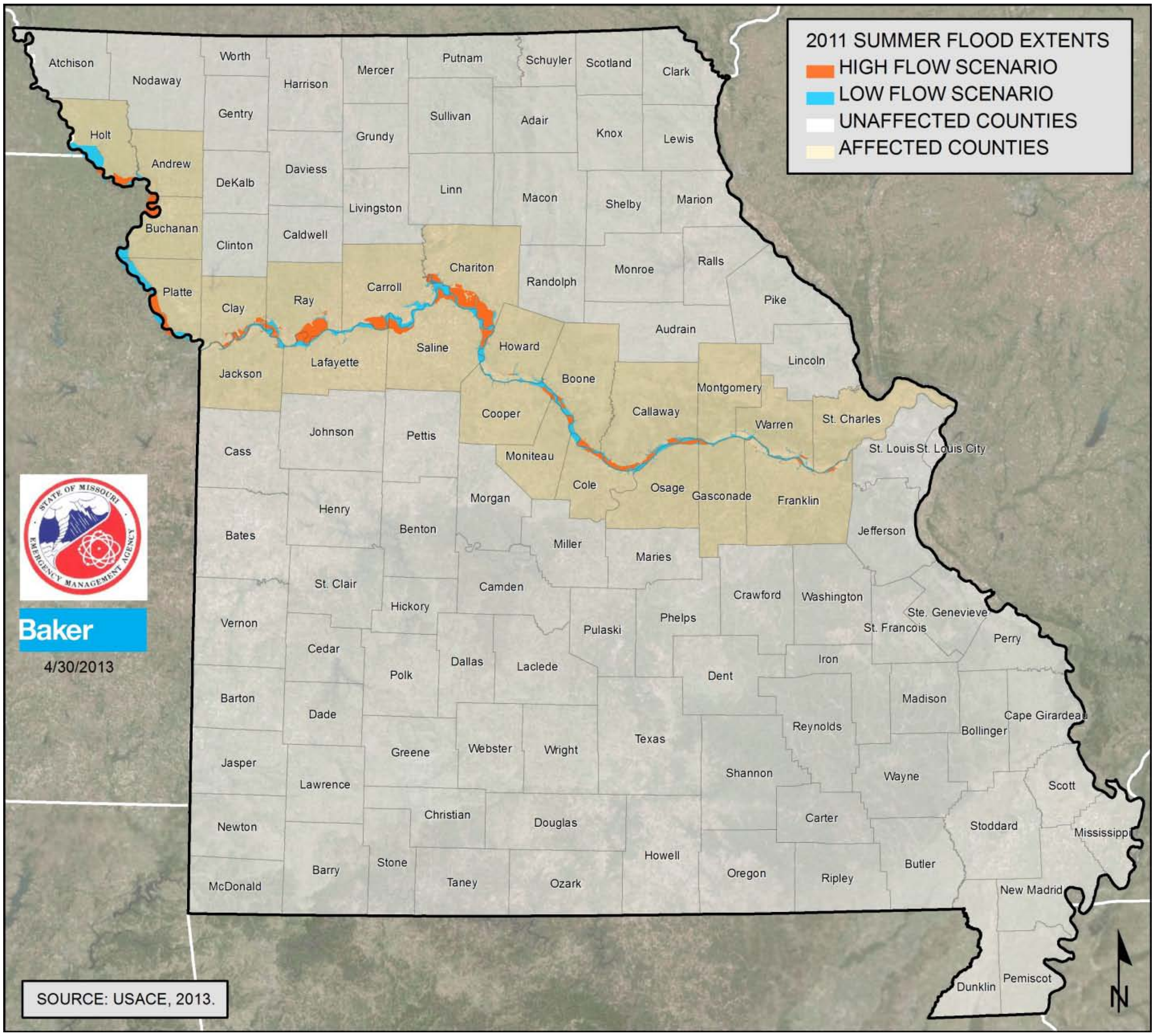
Summer 2011[17][18]

On July 25, 2011, a major disaster declaration was requested due to flooding during the period of June 1 to August 1, 2011 (Figure 3.3.1.4). The Governor requested a declaration for Individual Assistance for eleven counties, Public Assistance for 22 counties and Hazard Mitigation for the entire State of Missouri. During the period of July 18-22, 2011, joint federal, state, and local Preliminary Damage Assessments (PDAs) were conducted in the requested counties and are summarized below. PDAs estimate damages immediately after an event and are considered, along with several other factors, in determining whether a disaster is of such severity and magnitude that effective response is beyond the capabilities of the state and the affected local governments, and that Federal assistance is necessary.

---

[16] http://www.fema.gov/pdf/news/pda/1980.pdf
[17] http://www.fema.gov/pdf/news/pda/4012.pdf
[18] https://projects.mbakercorp.com/mohmpu13/Lists/Requests/Attachments/11/Bootheel_2011_Historic_Flood.pdf

Figure 3.3.1.4 - 2011 Summer Flood Extents



On August 12, 2011, the President declared that a major disaster exists in the State of Missouri. This declaration made Individual Assistance requested by the Governor available to affected individuals and households in Andrew, Atchison, Buchanan, Holt, Lafayette, and Platte Counties. This declaration also made Hazard Mitigation Grant Program assistance requested by the Governor available for hazard mitigation measures statewide.

The table below was pulled from a Corps of Engineers Vulnerabilities assessment concerning the 2011 flooding. It summarizes the studies research within each sector.

Table 3.3.1d 2011 Flood Vulnerability Report

2011 Flood Vulnerability Report			
Vulnerability Report Section	***Salient Feature Addressed***	***Key Points***	***Vulnerability/ Remaining Work***
Economics	Economic Impact to Basin	• Impacted 1+M acres, 10,000+ people, and almost 6,000 structures • Corps Reservoirs and emergency operations prevented nearly $8B in damages	• There is need to update Stage Damage Curves as well as Socioeconomic Data
Reservoirs and Water Management	Reservoir and Dam Infrastructure	• All critical assessments have been completed • Additional funding may be needed to restore system, pending studies	• Ft Peck Plunge pool and Ring Gates continue to be assessed and evaluated • Need to evaluate unlined spillways at Oahe and Pipestem • Some other Miscellaneous measures to restore existing systems • Depending on assessments, some operating restrictions may be implemented
	Water Management	• There are currently no formal operating restrictions on system • Record runoff that flowed into system needed to exit system	• Need to update Water Control Manuals • Implementing the 6 Independent External Panel Recommendations • Restore/maintain all project features to maximize flexibility in system

Vulnerability Report Section	*Salient Feature Addressed*	*Key Points*	*Vulnerability/ Remaining Work*
River Corridor and Conveyance	Floodway and Channel Performance	• Bank stabilization navigation projects, Navigation Channel, Habitat areas, and sedimentation and aggradation issues are being addressed and/or evaluated • Considerable damage did occur in river structures. Most known repairs funded	• Critical and high priority assessments and repairs are being addressed • Several river bends may require attention due to damage or flood determination • Additional studies may be required to fully assess channel condition • Complete the flow corridor study as planned
	Levees	• Critical repairs have been made • Some overtopping and under seepage was issue throughout basin	• Some flow constrictions exist in levee alignment • Repairs are funded but will carry into Fiscal Year 13
Other Considerations	Tribal and Cultural Resources	Cultural sites were impacted and are being assessed	• Tribes and others need to remain engaged thru Programmatic Agreement meetings and other partnering meetings
	Communications	• MRJIC worked to communicate and engage local state, and Federal and Tribal interests • MRFTF was a successful joint Federal effort to restore system	• MR Basin Interagency Roundtable(MRBIR) will inherit tasks/initiatives started by MR Flood Task Force (MRFTF)
Shared Responsibilities	Flood Risk Management	• Federal Government has little continue over local land uses• Federal Government has little continue over local land uses • Local and some states can help in reducing flood risk and expose	• Federal Government can assist when and if requested • MRBIR will continue the Stakeholder Communications started with MRFTF • To understand FRM, the 8 Authorized Purposes need continued education throughout the basin

Measure of Probability and Severity
Probability: High
Severity: High

In terms of overall damage, Missouri's most severe single hazard is flooding. Flooding has resulted in more federal disaster declarations in Missouri than any other hazard in the past three decades. Prior to the Great Flood of 1993, Missouri received major disaster declarations due to flooding in the spring of 1990, October 1986, June 1984, December 1982, August 1982 (Jackson County), April 1979, September 1977, May 1977, July 1976, June 1974, and for extensive flooding in April 1973 and again in November 1973.

Missouri's vulnerability to flooding higher because it is subject to flooding from two principal sources: the Missouri River Basin and the Upper Mississippi River Basin. According to SEMA, over one-third of the annual monetary losses due to flooding in the Missouri River Basin occur in Missouri.

Flash flooding can occur virtually anywhere in the State experiencing an abundance of rainfall in a very short time span, as with the November 1993 flood disaster and floods of 1998 and 1999. The backing up of tributary stream flows creates flooding problems along the Mississippi River, especially in the southern area of the State where the land tends to be very flat and at low elevations. Even though many flood control projects have been implemented and directly aid in flood prevention, the State is still flood-prone due to its geography and location.

The NWS has three response levels for alerting the public as to the danger of floods, as described in Table 3.3.1e.

Table 3.3.1e National Weather Service Flood Response Levels/Activities

Alert Level	Definition
Flood Watch	Atmospheric and hydrologic conditions are favorable for long duration areal or river flooding
Flood Warning	Long duration areal or river flooding is occurring or is imminent, which may result from excessive rainfall, rapid snow melt, ice jams on rivers or other similar causes
Flood Advisory	Thunderstorms have produced heavy rainfall that may result in ponding of water on roadways and in low-lying areas, as well as rises in small stream levels, none of which pose an immediate threat to life and property

Source: National Weather Service

The threat of flooding is more likely in the spring, when late winter or spring rains, coupled with melting snow, fill river basins with too much water too quickly. Spring also represents the onset of severe weather in the form of thunderstorms, tornadoes, and heavy rains, which can generate flash flooding along these storm fronts. As historically demonstrated, severe flooding can occur in Missouri at any time of the year. Based on this information, the State rates the probability and severity of floods as high.

Impact of the Hazard

FEMA estimates that more than 216,000 Missouri households are within the Special Flood Hazard Area. In addition, thousands of other Missouri residents are at risk to the dangers of flash flooding from

rapidly rising creeks and tributaries, storm water runoff, and other similar flooding events. Nationwide, most flood deaths are from flash floods, and nearly half of these fatalities are auto-related, according to the NWS.

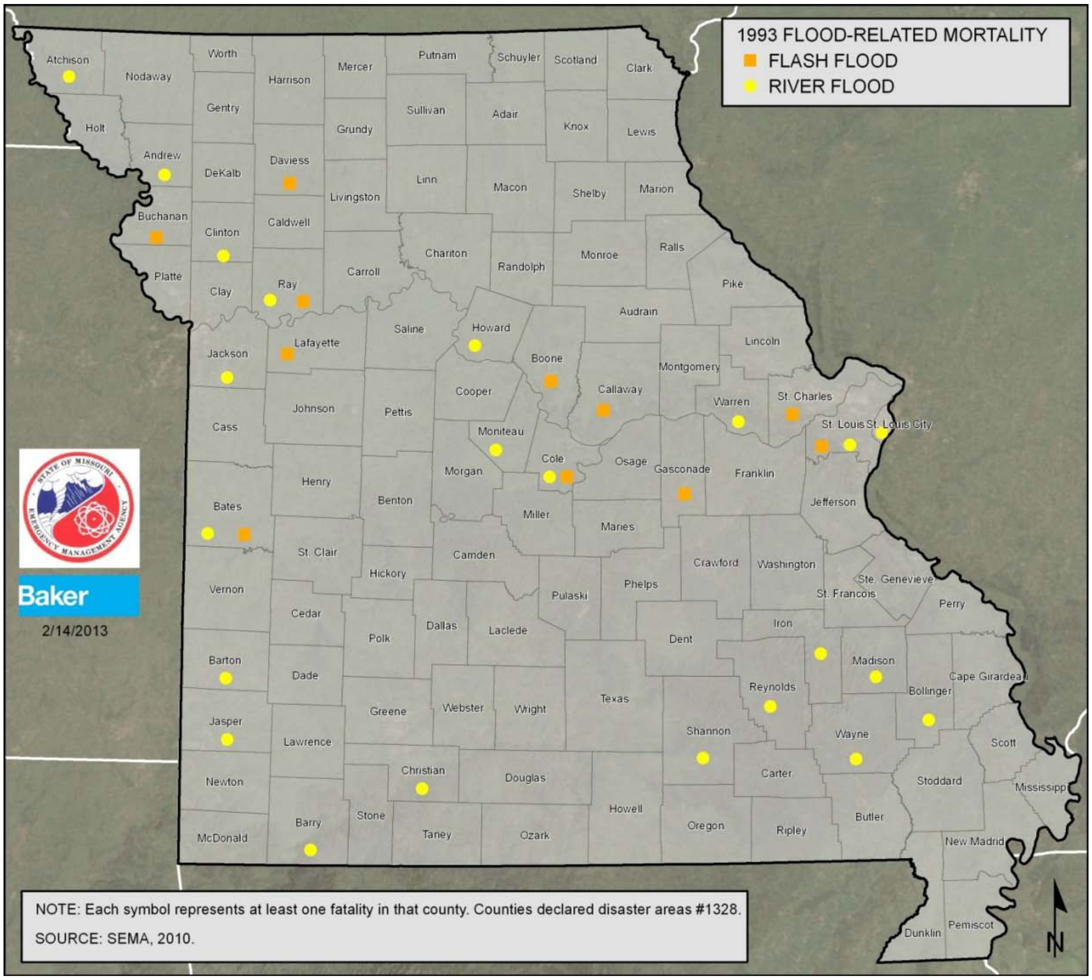
Of the 49 deaths recorded during the floods of 1993, 35 (71 percent) were from flash floods. In that same category, 20 deaths (77 percent) were related to motor vehicles caught in flash floods or attempting to cross high water. Missouri's river flooding in 1993 claimed 14 lives, with 6 deaths (23 percent) attributed to motor vehicles (see Table 3.3.1f and Figure 3.3.1.4).

Table 3.3.1f Summer/Fall 1993 Causes of Death by Type of Flood

Type of Death	River Flood	Flash Flood	Total
Motor Vehicle	6 (23%)	20 (77%)	26 (53%)
Drowning	5 (25%)	14 (74%)	19 (39%)
Electrocution	1 (50%)	1 (50%)	2 (4%)
Cardiac	2 (100%)	0	2 (4%)
All Causes	14 (29%)	35 (71%)	49 (100%)

Source: SEMA

Figure 3.3.1.4 - Flood-Related Mortality Missouri 1993



Missouri flood disasters have inflicted tremendous loss in terms of damage to personal property, businesses, infrastructure/public property, and agriculture. Total losses for all areas impacted during the 1993 flood disasters were estimated at approximately $3 billion. In addition, agricultural losses were estimated at $1.8 billion, as 3.1 million acres of farmland were either damaged or went unplanted because of the 1993 rains. The U.S. Department of Agriculture estimated that 445,000 acres of Missouri River bottomland were destroyed by washouts and sand scouring. While levees designed to protect up to 50-year floods did their jobs, the amount of rain and up-river flooding took their toll. Of the 1,456 public and private levees in the State, approximately 840 were damaged.

Almost every Missourian was at some time affected by the 1993 floods through inundation of roadways, airports, and drinking water and sewage treatment facilities, and by loss of income. The Missouri Department of Labor and Industrial Relations reported that $6.2 million was disbursed for disaster unemployment assistance for people who lost work due to flooding from July 1993 through March 1994. The floods of 1993 and 1994 pointed out that too many Missourians were living in a floodplain. To rebuild in the floodplains, those whose homes sustained substantial damage (50 percent or more) were required to elevate the structures above the base-flood level to protect from future flood damage. Under Missouri's Community Buyout Program, more than $30 million[19] in federal money was committed

[19] Not adjusted for inflation

to moving Missourians voluntarily out of the floodplains through the acquisition of primary residential properties. As a result of those actions, it is estimated that state taxpayers will save more than $200[20] million in future flood disaster claims.

The information in Table 3.3.1g is from the Impact Analysis of Potential for Detrimental Impacts of Hazards done for the Emergency Management Accreditation Program.

Table 3.3.1g EMAP Impact Analysis: Flooding

Subject	Detrimental Impacts
Health and Safety of Persons in the Area at Time of Incident	Localized impact expected to be severe for incident areas and moderate to light for other adversely affected areas.
Health and Safety of Personnel Responding to the Incident	Localized impact expected to limit damage to personnel in the flood areas at the time of the incident.
Continuity of Operations	Damage to facilities/personnel in the area of the incident may require temporary relocation of some operations.
Property, Facilities, and Infrastructure	Localized impact to facilities and infrastructure in the area of the incident. Some severe damage possible.
Delivery of Services	Localized disruption of roads, facilities, and/or utilities caused by incident may postpone delivery of some services.
The Environment	Localized impact expected to be severe for incident areas and moderate to light for other areas affected by the flood or HazMat spills.
Economic and Financial Condition	Local economy and finances adversely affected, possibly for an extended period of time.
Regulatory and Contractual Obligations	Regulatory waivers may be needed locally. Fulfillment of some contracts may be difficult. Impact may temporarily reduce deliveries.
Reputation of or Confidence in the Entity	Ability to respond and recover may be questioned and challenged if planning, response, and recovery not timely and effective.

Synopsis

Floods are often accompanied by other types of severe weather, including tornadoes, lightning, and severe thunderstorm activity. These storms also present a danger to life and property, often resulting in many injuries, and in some cases, fatalities. Floodwaters themselves often interact with hazardous materials. This has prompted the evacuation of many citizens near such materials stored in large containers that could break loose or puncture as a result of flood activity. Such events occurred during the 1993 flood, when approximately 11,000 St. Louis residents residing near flood-threatened propane tanks were evacuated on July 30. Evacuations were also ordered on July 31, when bulk propane tanks were flooded by the River Des Peres in St. Louis County. Federal and state agencies retrieved more than 247 large storage tanks; 1,178 small tanks; 3,470 large drums (over 15 gallons); and 5,731 small drums that had been swept away by the floods.

Public health concerns that may result from flooding include the need for disease and injury surveillance, community sanitation to evaluate flood-affected food supplies, private water and sewage sanitation, and vector control (for mosquitoes and other entomology concerns).

For additional information on vulnerability to flood, see Section 3.3.1.

[20] Not adjusted for inflation

3.3.2 Dam Failures

Description of Hazard

A dam is generally defined as an artificial barrier usually constructed across a stream channel to impound water. Since the passage of the 1979 Missouri House Bill 603, Missouri defines any artificial or man-made barrier which does or may impound water and which impoundment is thirty-five feet or more in height as a dam that requires regulation. The 1979 Missouri House Bill 603, as specified in Section 236.400 of the Revised Statutes of Missouri (RSMo.), excluded certain dams from regulation – those less than 35 feet high, and allowed exemptions for others – those used primarily for agricultural purposes, and those regulated by other state or federal agencies.

Federal law and the Association of State Dam Safety Officials (ASDSO) define a dam as "any artificial barrier, including appurtenant works, which impounds or diverts water, and which (1) is twenty-five feet or more in height from the natural bed of the stream or watercourse measured at the downstream toe of the barrier, or from the lowest elevation of the outside limit of the barrier, if it is not across a stream channel or watercourse, to the maximum water storage elevation; or (2) has an impounding capacity at the maximum water storage elevation of fifty acre-feet or more." Based on this definition, there are 87,359 dams recorded in the United States Army Corps of Engineers (USACE) National Inventory of Dams (NID) in the United States as of February, 2013.Over 95 percent of these dams are non-federal, with most being owned by state governments, municipalities, watershed districts, industries, lake associations, land developers, and private citizens. Dam owners have primary responsibility for the safe design, operation, and maintenance of their dams. They also have responsibility for providing early warning of problems at the dam, for developing an effective emergency action plan, and for coordinating that plan with local officials. The state has ultimate responsibility for public safety; many states regulate construction, modification, maintenance, and operation of dams and also implement a dam safety program.

A dam failure is characterized by an uncontrolled release of water from behind a dam. Flooding, earthquakes, blockages, landslides, lack of maintenance, improper operation, poor construction, vandalism, and terrorism can all cause a dam to fail. When a dam failure occurs, an enormous amount of water is suddenly released, destroying infrastructure and flooding the area downstream of the dam.

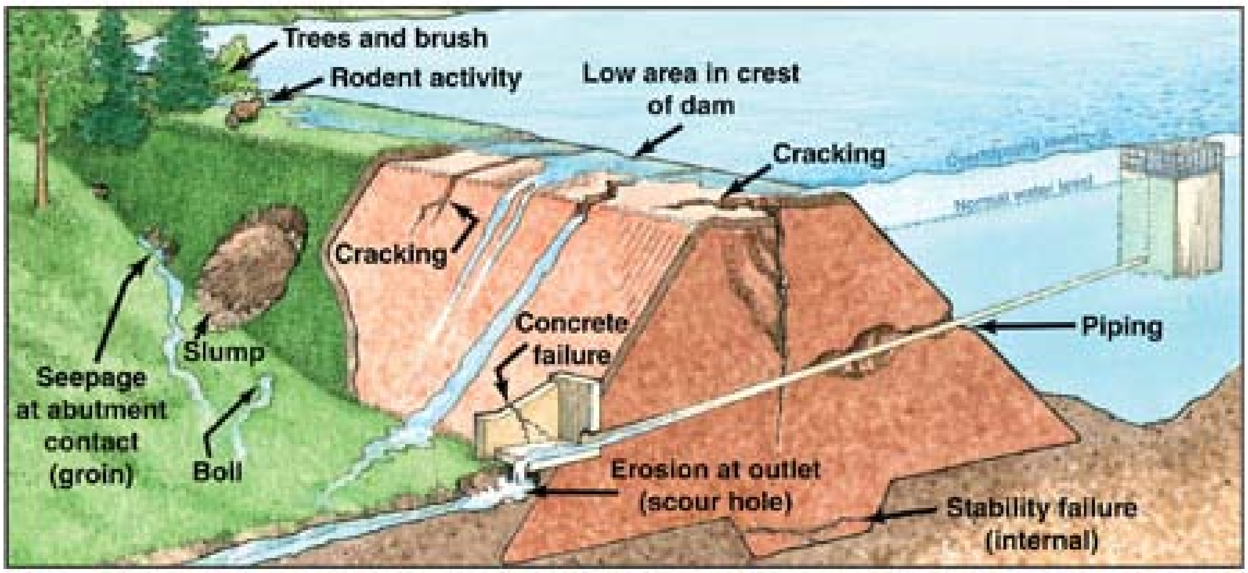
Dams can fail for many reasons. The most common are as follows:

- **Overtopping** – inadequate spillway design, debris blockage of spillways, or settlement of the dam crest;
- **Piping**—Internal erosion caused by embankment leakage, animal burrows, foundation leakage, and/or deterioration of pertinent structures appended to the dam;
- **Erosion**—flow erosion, and/or inadequate slope protection;
- **Structural Failure**—caused by an earthquake, slope instability, and/or faulty construction.

The four types of failures are often interrelated. For example, erosion, either on the surface or internal, may weaken the dam, which could lead to structural failure. Similarly, a structural failure could shorten the seepage path and lead to a piping failure. Observable defects that provide good evidence of potential dam failures are illustrated in Figure 3.3.2.1 Possible Dam Failures.

Over the years, dam failures have injured or killed thousands of people and caused billions of dollars in property damage in the United States. Among the most catastrophic were the failures of the Teton Dam in Idaho in 1976, which killed 14 people and caused more than $1 billion in damage, and the Kelly-Barnes Dam in Georgia in 1977, which left 39 dead and $30 million in property damage. The problem of unsafe dams in Missouri was underscored by dam failures at Lawrenceton in 1968, Washington County in 1975, Fredricktown in 1977, and the December 14, 2005, collapse of the Upper Reservoir of AmerenUE's Taum Sauk hydroelectric complex in Reynolds County. Many of Missouri's smaller dams are becoming a greater hazard as they continue to age and deteriorate. Hundreds of dams are in need of rehabilitation, however a lack of funding and questions of ownership have made it difficult to implement the necessary maintenance.

Figure 3.3.2.1 - Possible Dam Failures



Source: United States Forest Service: http://www.fs.fed.us/eng/pubs/htmlpubs/htm12732805/page02.htm

Dam construction varies widely throughout the State. The majority of dams in Missouri are earthen dams, which means they are constructed as a simple embankment of well compacted earth. Missouri's mining industry has produced numerous tailing dams for the surface disposal of mine waste. These dams are made from mining material deposited in slurry form in an impoundment. Other types of earthen dams are reinforced with a core of concrete or asphalt. The largest dams in the State are built of reinforced concrete and are used for hydroelectric power.

Regulatory Framework

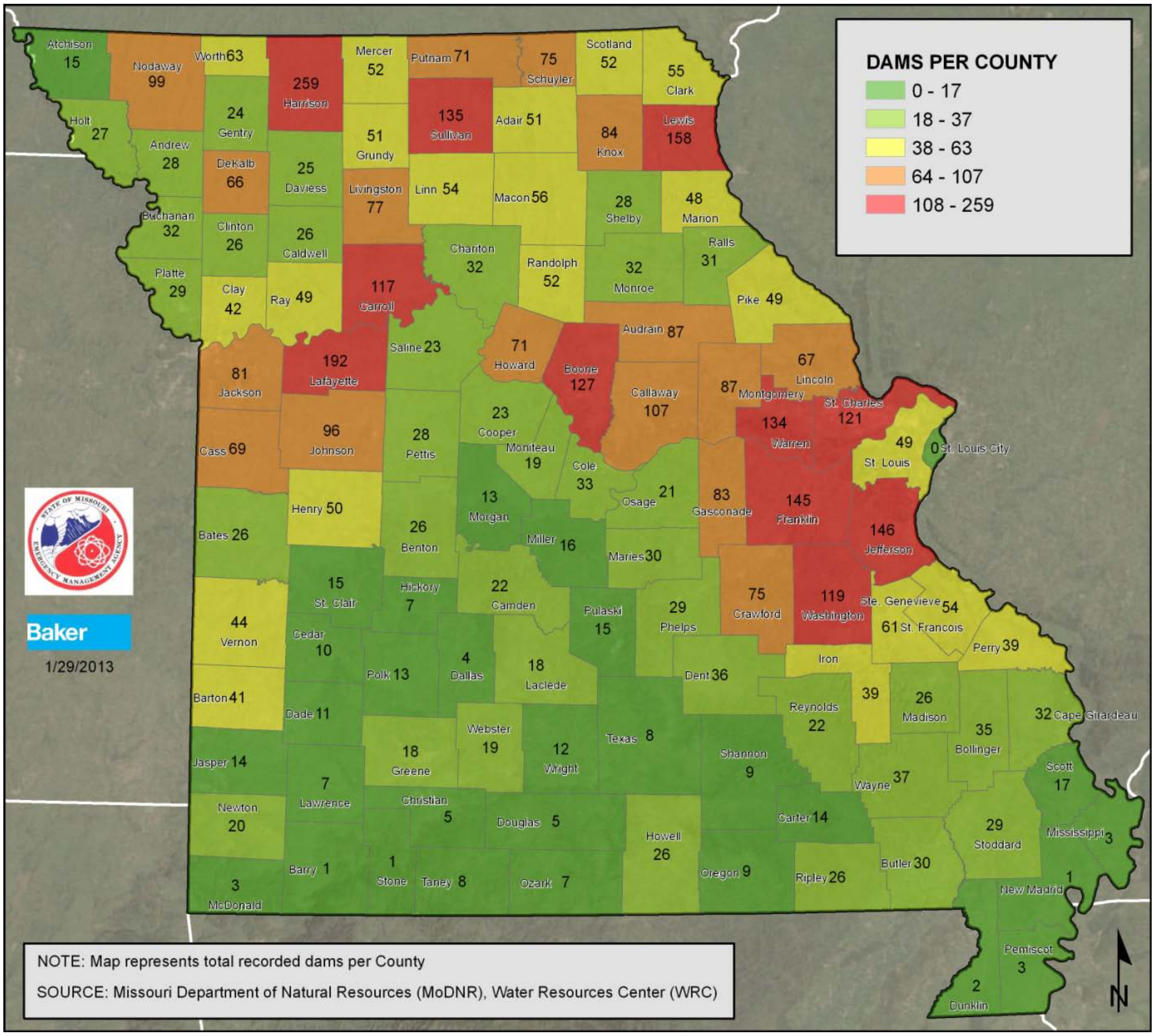
The overlapping responsibilities for many natural hazards that are shared by multiple state and federal agencies, especially flooding, can be challenging to clearly understand. Complicating this, many agencies have different divisions, districts, communities of practice and stovepipes that work together. According to the Missouri Department of Natural Resources (MDNR). Missouri currently has 5,243 recorded dams. This includes all regulated and unregulated dams for all types of dam owners (federal, state, local, or private). Figure 3.3.2.2 provides the number of recorded dams by county in Missouri.

The topography of the State allows lakes to be built easily and inexpensively, contributing to the high number of dams. Despite the large number of dams, there are only 682 (about 13 percent) state regulated dams, with an additional 66 federally regulated dams. Federal dams in Missouri are primarily regulated by two federal agencies; the U.S. Army Corps of Engineers (USACE), and the U.S. Department of Agriculture Forest Service. The Federal Energy Regulatory Commission (FERC) regulates some dams under the 1920 Federal Power Act. These dams are permitted under their FERC permits. Other federally regulated dams are owned by the Department of Defense, the Department of Interior, electric power providers, and other entities. The remaining 4,495 dams are unregulated.

Dams that fall under state regulation are non-federally regulated dams that are more than 35 feet in height. Most nonfederal dams are privately owned structures built either for agricultural, water supply or recreational use. Missouri also has more than 1000 dams that were built as small watershed projects under Public Law-566 (Watershed Protection and Flood Prevention Act of 1953). These dams serve many functions, including flood control, erosion control, recreation, fish and wildlife habitat, water supply, and water quality improvement. Many of these PL 83-566 dams need ongoing maintenance to safely provide these functions. Another group of older dams in the State were originally built by railroad companies as holding ponds for water to be used in steam locomotives. Many of these are now used as drinking water reservoirs by nearby towns and cities. Finally, there are many mining dams that are no longer in use and have been sold to private individuals.

Within the State of Missouri, the Department of Natural Resources (MDNR) Water Resources Center maintains a Dam and Reservoir Safety Program. The objective is to ensure that dams over 35 feet in height are safely constructed, operated, and maintained pursuant to Chapter 236 Revised Statutes of Missouri. These dams are inspected by a professional engineer at least once every 5 years. The majority of dams in Missouri are less than 35 feet high and are thus, not regulated. While the State has encouraged dam owners to have these unregulated dams inspected for many years, the MDNR lacks the authority to assess the condition of these dams and any downstream hazards.

Figure 3.3.2.2 - Total Recorded Dams in Missouri by County



Dams of Missouri

The Department of Natural Resources provides information about regulated and unrelated dams at the website http://dnr.mo.gov/env/wrc/damsft/statemap.htm. The information includes details of the dam dimensions, date of construction, approximate reservoir volume, contributing drainage basin area and hazard classification. Users are able to select from two options: a report that provides information on a county basis, or a map that displays the approximate location of the dam and whether it is regulated or unregulated.

The information provided by the website was developed from the National Inventory of Dams (NID) database and provides users with a dam safety resource that is both graphic and searchable. The Department's Dam and Reservoir Safety Program used the NID as the basis for the creation of the website products. It is important to note that the original NID was created nearly 30 years ago and users should be advised that the information provided, especially for unregulated dams, may no longer be representative and/or accurate. The Dam and Reservoir Safety Program periodically provides updated information to the United States Army Corps of Engineers when discrepancies are noted in the NID or when new information becomes available.

State Regulated Dams

The Missouri Department of Natural Resources (MDNR), Water Resources Center is responsible for ensuring that all new and existing non-agricultural, non-federal dams 35 feet or higher meet the minimum safety standards established by the Dam and Reservoir Safety Law. The Missouri DNR has three classifications for all state-regulated dams:

> **Class 1:** The area downstream from the dam that would be affected by inundation contains ten (10) or more permanent dwellings or any public building. Inspection of these dams must occur every two years.
>
> **Class 2:** The area downstream from the dam that would be affected by inundation contains one (1) to nine (9) permanent dwelling, or one (1) or more campgrounds with permanent water, sewer and electrical services or one (1) or more industrial buildings. Inspection of these dams must occur once every three years.
>
> **Class 3:** The area downstream from the dam that would be affected by inundation does not contain any of the structures identified for Class I or Class II dams. Inspection of these dams must occur once every five years.

Since 2009, the MDNR has been working with dam owners and emergency personnel to develop Emergency Action Plans (EAP) for all 460 state regulated, high-hazard potential dams in Missouri. High Hazard dams are defined as a dam located in an area where failure could result in any of the following: extensive loss of life, damage to more than one home, damage to industrial or commercial facilities, interruption of a public utility serving a large number of customers, damage to traffic on high-volume roads that meet the requirements for hazard class C dams or a high-volume railroad line, inundation of a frequently used recreation facility serving a relatively large number of persons, or two or more individual hazards described for significant hazard dams. To date, over 180 EAPs have been completed by dam owners with the assistance of their county emergency management directors (EMD). Each EAP contains a guide to dam emergencies, a list of available material resources, notification list, a list of at-risk structures, and an inundation map. Upon completion, the dam owner provides a copy of the EAP to the MDNR and the county EMD.

A key part to completing an EAP is the inundation map, showing the area downstream from the dam that would be inundated if the dam were to fail. Inundation maps are provided to dam owners by MDNR along with an EAP template. Inundation maps are also provided to each county's recorder of deeds, as required by law. To date, 370 inundation maps have been completed and presented to dam owners. The inundation zones from these maps are included in the population exposure and critical facilities vulnerability assessment in this State Hazard Mitigation Plan. Inundation zones represent flooding resulting from sudden releases of water impounded behind earthen dams. Using the EAP, county and

local emergency management officials can identify the location of residences, businesses, farms and ranches, schools, hospitals, nursing homes, and highways at risk, shelters and emergency resources, and other information crucial for an efficient response, including evacuation procedures and routes if needed.

Figures 3.3.2.3 and Figure 3.3.2.4 provide all currently mapped inundation zones and an example of an inundation map title sheet provided for Adams Dairy Parkway Dam.

Figure 3.3.2.3 – Dams with Mapped Inundation Areas for Class 1 and Class 2 State-Regulated Dams

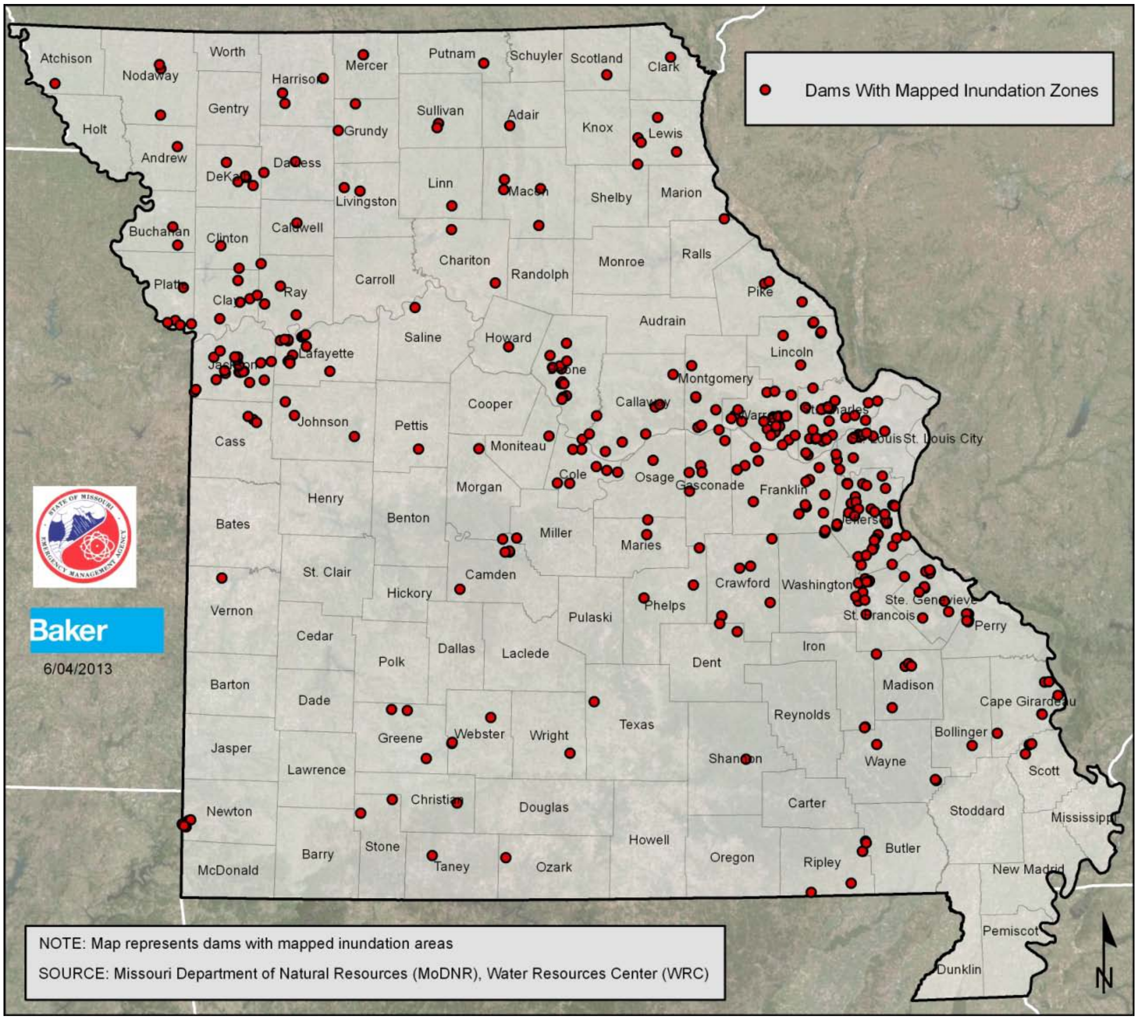
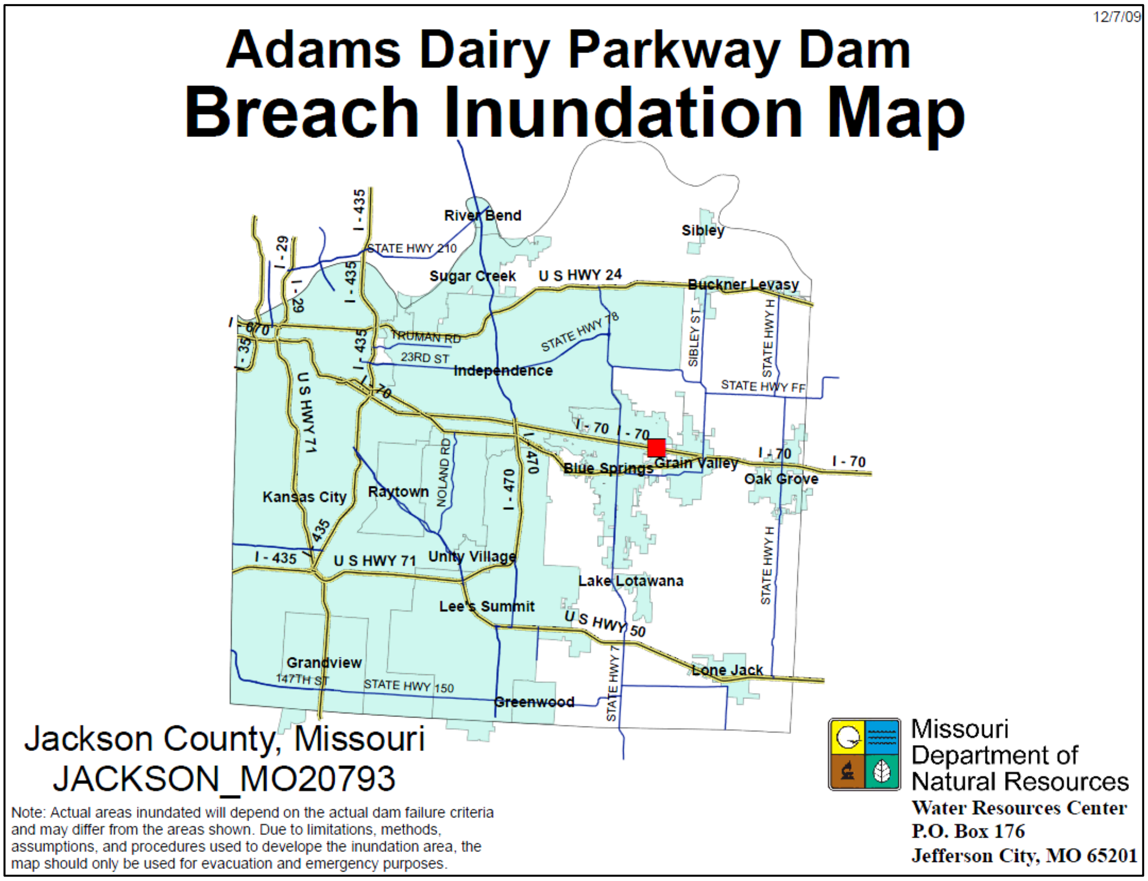


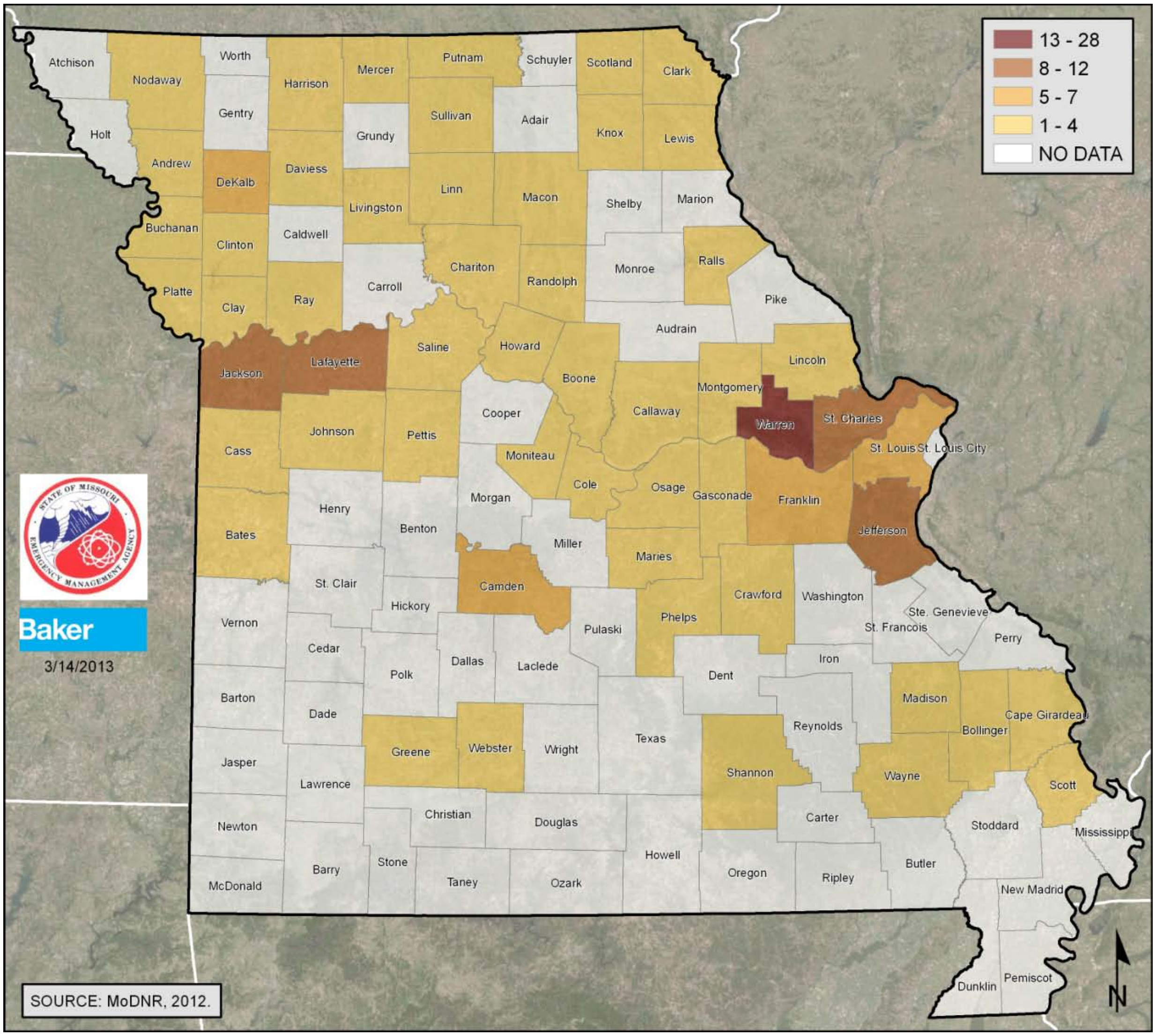
Figure 3.3.2.4 - Missouri Department of Natural Resources Breach Inundation Analysis – Adams Dairy Parkway Dam



Persons at risk also may include farm workers, hunters, anglers, hikers, campers and other recreationists. Livestock also may be endangered. An EAP also helps emergency managers show the structures that are at risk and the roads that will be flooded so that emergency managers can plan escape routes and emergency efforts accordingly. A copy of the EAP template that was developed by the Missouri Department of Natural Resources and can be found on their Dam and Reservoir Safety Program Emergency Action Planning webpage. Figure 3.3.2.4 is an example of the maps produced for all the state managed high hazard dams as part of their EAPs.

Figure 3.3.2.5 provides the number of dams with Emergency Action Plans, per county.

Figure 3.3.2.5 - Number of Dams with Emergency Action Plans



In Missouri, there are a total of 682 state-regulated dams. Of those, 203 are Class 1, 255 are Class 2, and 224 are Class 3 dams. When considering the Hazard Potential Classifications of the National Inventory of Dams (NID), of the 682 state-regulated dams, 460 are considered High Hazard Dams. There is not a direct correlation between the State Hazard classification and the NID classifications. However, most dams that are in the State's Classes 1 and 2 are considered NID High Hazard Dams.

Table 3.3.2a breaks down the number of state-regulated dams by county and indicates the State hazard potential classification of those dams in each county. Figure 3.3.2.6 illustrates the total number of state-regulated dams by county.

Table 3.3.2a State-Regulated Dams in Missouri by County and the Hazard Potential Classification in Each County

County	Number of Dams	Hazard Potential Classification		
		Class 1	Class 2	Class 3
Adair	3	0	1	2
Andrew	1	1	0	0
Atchison	6	0	1	5
Audrain	0	0	0	0
Barry	0	0	0	0
Barton	0	0	0	0
Bates	1	1	0	0
Benton	3	0	0	3
Bollinger	1	0	1	0
Boone	17	4	10	3
Buchanan	4	1	1	2
Butler	0	0	0	0
Caldwell	2	0	1	1
Callaway	19	1	6	12
Camden	12	2	7	3
Cape Girardeau	6	3	3	0
Carroll	0	0	0	0
Carter	0	0	0	0
Cass	5	4	0	1
Cedar	1	0	0	1
Chariton	4	0	1	3
Christian	2	0	1	1
Clark	3	1	0	2
Clay	5	2	1	2
Clinton	4	2	1	1
Cole	8	4	3	1
Cooper	2	0	0	2
Crawford	10	1	4	5
Dade	0	0	0	0
Dallas	0	0	0	0
Daviess	5	0	3	2
DeKalb	10	1	5	4
Dent	4	0	2	2
Douglas	0	0	0	0

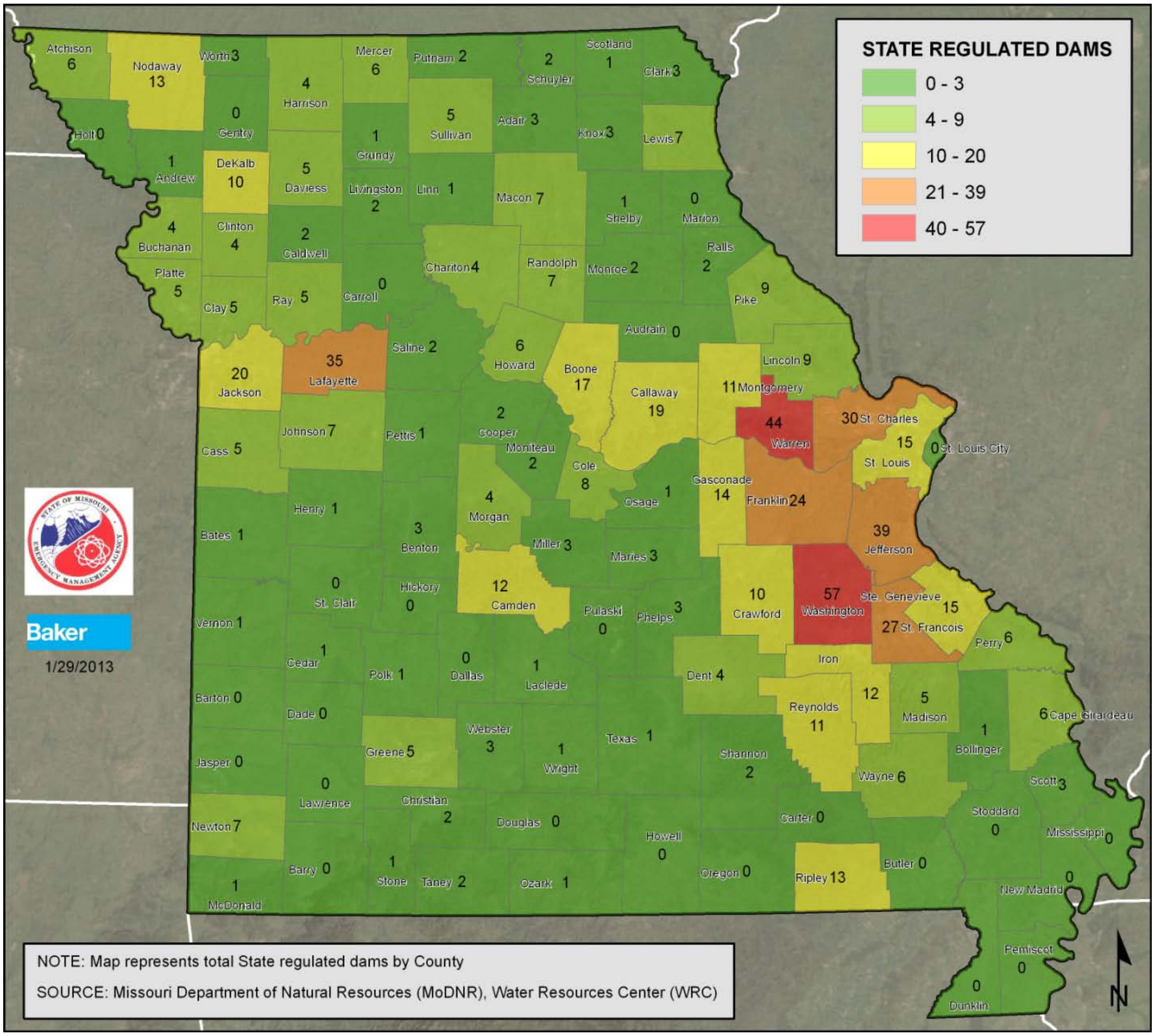
County	Number of Dams	Hazard Potential Classification		
		Class 1	Class 2	Class 3
Dunklin	0	0	0	0
Franklin	24	7	9	8
Gasconade	14	4	3	7
Gentry	0	0	0	0
Greene	5	2	2	1
Grundy	1	0	0	1
Harrison	4	1	2	1
Henry	1	0	0	1
Hickory	0	0	0	0
Holt	0	0	0	0
Howard	6	1	0	5
Howell	0	0	0	0
Iron	12	5	4	3
Jackson	20	16	2	2
Jasper	0	0	0	0
Jefferson	39	21	14	4
Johnson	7	2	1	4
Knox	3	0	1	2
Laclede	1	0	0	1
Lafayette	35	0	14	21
Lawrence	0	0	0	0
Lewis	7	0	4	3
Lincoln	9	3	3	3
Linn	1	1	0	0
Livingston	2	1	1	0
McDonald	7	2	3	2
Macon	5	1	4	0
Madison	3	0	2	1
Maries	0	0	0	0
Marion	1	0	0	1
Mercer	6	2	2	2
Miller	3	0	0	3
Mississippi	0	0	0	0
Moniteau	2	2	0	0
Monroe	2	0	0	2
Montgomery	11	2	3	6

County	Number of Dams	Hazard Potential Classification		
		Class 1	Class 2	Class 3
Morgan	4	0	0	4
New Madrid	0	0	0	0
Newton	7	5	2	0
Nodaway	13	1	2	10
Oregon	0	0	0	0
Osage	1	1	0	0
Ozark	1	0	1	0
Pemiscot	0	0	0	0
Perry	6	2	4	0
Pettis	1	1	0	0
Phelps	3	2	1	0
Pike	9	1	3	5
Platte	5	4	1	0
Polk	1	0	0	1
Pulaski	0	0	0	0
Putnam	2	0	1	1
Ralls	2	1	0	1
Randolph	7	1	0	6
Ray	5	2	3	0
Reynolds	11	7	1	3
Ripley	13	0	6	7
St. Charles	2	0	1	1
St. Clair	2	0	0	2
St. Francois	1	1	0	0
Ste. Genevieve	3	2	1	0
St. Louis	2	0	1	1
St. Louis City*	1	0	0	1
Saline	30	9	17	4
Schuyler	0	0	0	0
Scotland	27	8	14	5
Scott	0	0	0	0
Shannon	15	9	3	3
Shelby	15	7	5	3
Stoddard	0	0	0	0
Stone	1	1	0	0
Sullivan	5	1	1	3

County	Number of Dams	Hazard Potential Classification		
		Class 1	Class 2	Class 3
Taney	2	0	1	1
Texas	1	0	1	0
Vernon	1	0	0	1
Warren	44	9	23	12
Washington	57	24	30	3
Wayne	6	3	2	1
Webster	3	0	3	0
Worth	3	0	0	3
Wright	1	0	1	0
Totals	**682**	**203**	**255**	**224**

Source: Inventory of Dams, Missouri Department of Natural Resources, Dam and Reservoir Safety

Figure 3.3.2.6 - State-Regulated Dams by County



Unregulated Dams

Over 3,700 dams in Missouri (more than 70%) do not meet the height requirements for state-regulation. Many of these dams have gone unchecked for decades because there is no legal authority or state allocated manpower available to inspect them. Dams that do not get regular attention can erode over the years, or may be damaged by floods. These dams can be considered vulnerable. If a dam fails, the owner is responsible for the damages that may be caused, regardless of whether or not the dam is state regulated.

Federal Regulated Dams

There are 63 federally-regulated dams in Missouri. All federally-regulated dams fall outside the regulatory authority of the Missouri Dam and Reservoir Safety Program. Table 3.3.2b on the follow page summarizes the federally owned or regulated dams that are located in Missouri, by county. The two federal agencies responsible for most of these dams are the U.S. Army Corps of Engineers (USACE) and

the U.S Department of Agriculture Forest Service. Other federally regulated dams are owned by the Department of Defense, Department of Interior, electric power providers, and other entities. The Federal Energy Regulatory Commission (FERC) oversees the inspection of power generation dams in Missouri such as the facilities at Taum Sauk and the Bagnell Power Station at the Lake of the Ozarks.

Table 3.3.2b

COUNTY	NUMBER OF FEDERALLY OWNED OR REGULATED DAMS
BENTON	2
BUTLER	1
CAMDEN	1
CARTER	1
CEDAR	1
CHARITON	3
CLAY	1
DENT	1
HENRY	3
HICKORY	1
HOLT	1
HOWELL	2
IRON	2
JACKSON	7
LEWIS	1
LINCOLN	1
MACON	1
MARION	1
MILLER	1
OREGON	1
PHELPS	1
PIKE	1
PULASKI	7
RALLS	3
REYNOLDS	2
RIPLEY	2
SHANNON	2
ST. CLAIR	1
ST. LOUIS CITY	1
TANEY	2
TEXAS	2
WASHINGTON	1
WAYNE	5
Grand Total	63

Extensive care is taken in the design, construction, and operation of the USACE dams. As a result, the USACE record for dam safety is considered excellent. In Missouri, twelve dams are maintained and operated by the USACE. Of those maintained by the USACE, seven are maintained by the Kansas City District, three are maintained by the Little Rock District, and two are maintained by the St. Louis District. Several relevant USACE Civil Works programs overlap with the State Risk Management Team (SRMT) in Missouri. The Silver Jackets, for example, is the USACE Civil Works program that enables participation in the state hazard mitigation teams through a collaborative effort between USACE, the Federal Emergency Management Agency, and other federal, state and local agencies to create an interagency team at the state level to develop and implement solutions to state natural hazard priorities. The lead coordinator for the Silver Jackets provides regular status updates and participates on the SRMT, representing all the USACE districts within the state at the team meetings. Each district has a Silver Jacket Coordinator, whom is encouraged to attend. The status updates provide detail information on active USACE Civil Works projects and programs, including specific project information that is useful during the FEMA Risk MAP Discovery Phases.

Inundation Maps

Inundation maps for USACE dams are in various stages of development, and the USACE Modeling, Mapping, and Consequences (MMC) Production Center, which is part of the USACE Risk Management Center, are producing these maps. The maps' index sheets show two important elements about a possible dam break that inform possible hazard mitigation actions, especially for local hazard mitigation plans to consider. First, a regional look at the extent of possible inundation, and the second are travel times for the peak flow at various points along the rivers for a potential dam break. USACE is having the MMC complete these maps as soon as funding and staffing allows.

Interim Risk Reduction Measures (IRRMs)

The USACE is actively engaged in a program to assess and communicate risk associated with dams and levees. Actions to reduce inundation risks associated with USACE programs have been termed interim risk reduction measures (IRRMs). IRRMs are temporary actions taken to reduce inundation risks posed by dams and/or levees while longer term solutions are planned and implemented. The IRRMs do not preclude or in any way replace long term measures needed to reduce any risk. IRRMs are a critical part of responsible, adaptive flood risk management and recognize the dynamic nature of flood risk. In establishing IRRMs, the prevention of loss of life is the highest priority.

These IRRMs can be non-structural or structural (see examples of IRRMs below), and focus on temporary measures. Interim measures should not induce additional risks beyond what the dam safety deficiency present. Interim measures would be timely, and implemented within 6 months or less. Some interim measures, whether structural or non-structural, may become permanent based on the recommendations of a USACE study or report. A prime example of hazard mitigation action, in some case containing the IRRMs, is the emergency action plan for a dam.

Flood risk is a shared responsibility including communities and residents within the flood plain, owners & operators of dams and levees, owners and operators of infrastructure within the flood plain, and agencies with jurisdiction for emergency management and evacuation authority. Local residents, especially those living within a dam inundation area, are expected to know their risk. One key public message is that flood risk mitigation projects (including dams and levees) reduce risk; they do not eliminate it.

The USACE has implemented IRRMs at many of its dams. IRRMs completed in the last several years have included open houses to communicate risk assessment result with the public, EAP updates, orientation seminars with EAP plan holders, new instrumentation for monitoring dam performance, some specific engineering evaluations, and some expedited repairs.

Examples of non-structural Interim Risk Reduction Measures for Dams (hazard mitigation actions) include:

1. Reservoir pool restrictions or change in water control plan the district should begin immediate action to update the water control plan to reflect the operational change or pool restriction.
2. Guidance is provided in ER 1110-2-240, Water Control Management (Reference A.49) for water control plan deviations and updates. In the interim a deviation from the current water control plan should be implemented until the water control plan is updated to reflect the operational change or pool restriction. Regulation plan changes must be documented, and formal deviation requests from the Water Control Plan must be approved by the MSC.
3. Annual command level reviews of IRRM implementation are required for DSAC I, II, and III dams and revision to the IRRM plan are to be made as necessary. These reviews should also include review of the communication plans with stakeholder engagement and public involvement plans.
4. Pre-position emergency contracts for rapid supply of other needed items/equipment.
5. Stockpiling emergency materials, e.g., rock, sand, sand bags, emergency bulkheads, or other operating equipment, etc.
6. Use of other reservoirs in the system may be required to mitigate the impact of regulation schedule changes. If the change in regulation schedule is required for other dams in the system, then a regulation deviation for those dams would be required as well.
7. Improved and/or increased inspection and monitoring to detect evidence of worsening conditions to provide an earlier warning to the public for evacuation.
8. Update the Emergency Action Plan and the inundation mapping to include project-specific failure mode(s). The NWS must be included in the EAP to take advantage of their television/radio announcement and stream forecasting capabilities. The Modeling, Mapping, and Consequence Production Center (MMC) has overall responsibility for developing dam failure, inundation mapping, and consequence models for USACE dams in support of the EAP.
9. Explicit procedures, communications systems, and training of appropriately skilled team members for prompt and effective emergency response by the USACE in the event of the detection of worsening or catastrophic conditions. Refer to Chapter 16 for guidance on the appropriate type and frequency of exercises.
10. Conduct appropriate emergency exercises that plan for a range of failure scenarios (including the combined effects of multiple failure modes and different timing of detection) to improve warning and evacuation times.
11. Coordination with local interests and Federal and non-Federal agencies, including the National Weather Service (NWS) and local Emergency Management Agencies (EMA), with a focus on the specific failure mode(s) and the effectiveness of response including appropriate response exercises.
12. Identify instrumentation/monitoring “trigger” or threshold pools that would initiate more urgent monitoring or emergency response. In addition, threshold values should be established for instrument readings where possible.
13. Installation of early warning systems to increase evacuation percentage and time.

14. Preventive maintenance and repairs such as cleaning drains and improving spillway gate reliability where non-functioning components would exacerbate the existing conditions in an emergency.

Examples of structural Interim Reduction Measures for Dams (hazard mitigation actions) include:

1. Isolate problem area (e.g., cofferdam around problem monolith(s) or other project feature).
2. Improve seepage collection system.
3. Lower the spillway crest to aid in prevention of failure (A consequence estimate may be warranted to ensure overall risk is not increased by this measure).
4. Increase spillway capacity/construct another spillway. (A consequence estimate may be warranted to ensure overall risk is not increased by this measure).
5. Breach/lower saddle dams along the reservoir perimeter. (A consequence estimate may be warranted to ensure overall risk is not increased by this measure).
6. Strengthen weak areas (e.g., upstream or downstream blanket to cut off/slow seepage; install tie-backs/anchors; and install additional buttresses).
7. Construct a downstream dike to reduce head differential.
8. Construct stability berm.
9. Increase dam height. (A consequence estimate may be warranted to ensure overall risk is not increased by this measure).
10. Modify outlet discharge capability such as by installing temporary siphon(s).
11. Increase erosion protection where necessary.
12. Protect downstream critical facilities (e.g., medical and emergency services).
13. Construct shallow cutoff trench to slow seepage.
14. Target grout program specifically for suspected problem area(s) to slow seepage.
15. Remove significant flow restrictions (downstream bridge conditions may restrict maximum discharge from the outlet works. Upstream bridges or small dams may restrict flow caused by debris buildup that could result in a large release).

Emergency Action Plans

Each USACE dam has an emergency action plan (EAP). These EAPs get updated generally on an annual basis, and a copy of the EAP for each dam is also sent to the state hazard mitigation officer (SHMO) at SEMA. At the local level, the county emergency managers also get a copy from the dam safety project manager within each USACE district. The generic IRRMs mentioned in USACE guidance documents can include two categories, structural or non-structural.

In addition to IRRM's and EAPs, the Kansas City District of USACE created fact sheets for dams they are prioritizing for risk evaluation. The fact sheets identify the location and physical characteristics of each dam, the risk evaluation concerns, and current and future actions being made to reduce the risk of dam failures. The information from these fact sheets are summarized in Table 3.3.2c below.

Table 3.3.2c USACE Risk Evaluation Fact Sheet Summaries

Dam Name	Dam Location	Physical Characteristics	Risk Evaluation Concerns	Current Actions	Possible Future Actions
Pomona	110 Mile Creek, 9 miles northwest of Pomona, Kansas	7,750 feet long earth fill embankment, 111 feet in height	• Foundation rock is jointed and may have small cavities allowing seepage during high pool • Less filtration; concerns regarding stability and seepage • Riprap on the upstream dam face is weathered and degraded, could lead to erosion	• Surveying the drainage ditch profile, proposing to take weir flow measurements at the foundations drain • Update Surveillance and Emergency Action Plans • Scheduling coordination meeting with emergency management officials • Open house and public communication	• Additional instrumentation • A stability analysis
Rathbun	Chariton River, Appanoose County, approximately 5 miles north of Centerville, Iowa	Two earthen embankments; main embankment is 8,160 feet long, 100 feet in height; second embankment is 1,960 feet long and 75 feet in height	• Seepage through sand layers during high pool events • Inadequate stilling basin for large releases • Spillway erosion • Embankment stability • Seepage along the conduit	• Scour protection around stilling basin walls and outlet channel • Buried drain installed at the Buck Branch left abutment • Investigation of an upstream seepage blanket at Buck Branch • Orientation seminar with local emergency management officials • Surveillance and monitoring plan update for high risk concerns	

Dam Name	Dam Location	Physical Characteristics	Risk Evaluation Concerns	Current Actions	Possible Future Actions
Smithville	Little Platte River, river mile 13.2, about two miles northeast of Smithville, Missouri	4,000 ft long earthen embankment, 75 ft in height	• Embankment seepage and stability concerns at left abutment • Leakage from pressurized water supply pipe adjacent to the outlet work conduit • Seepage and instability at the right abutment, main dike and conduit	• Stability reanalysis of the left abutment to establish threshold values for the piezometers and provide guidelines for maintenance requirements • Installation of additional instrumentation to measure water pressures, ground deformations and temperatures	• Update the dam surveillance plan to target concerns • Conduct orientation seminar with Emergency management officials • Perform remedial actions and repairs based on findings and recommendations of dam reanalysis
Stockton	Sac River, Cedar County, Missouri, approximately two miles east of Stockton, Missouri	Earth and rock filled embankment with powerhouse and spillway; main embankment is 5,100 feet long, 128 feet in height	• Foundation rock is jointed and may have small cavities • Seepage problems could occur at the embankment transition from rock fill to soil fill where filtration is critical to long-term performance problems	• Hydropower intake tube has been repaired • Piers were inspected and evaluated for corrosion of the steel bars, and caulk on the spillway piers has been replaced • Seven instruments to measure water levels below the spillway structure were replaced • A new instrument to monitor seepage was installed on the right abutment • Scheduling coordination meeting with emergency management officials • Open house and public communication	• Pool evacuation plan for emergency actions • Updating EAP • Evaluation of embankment filter construction records • Document performance assessment for earthquakes • Additional embankment piezometers to target grout curtain effectiveness

Dam Name	Dam Location	Physical Characteristics	Risk Evaluation Concerns	Current Actions	Possible Future Actions
Wilson	Saline River, Russell County, Kansas, about 50 miles west of Salina	5,600 feet long embankment, 157 feet in height	• Seepage occurring at both abutments attributed to sandstone joints • The sandstone joints have openings up to several inches in width that were filled with clay. The joint condition and possible washout of clay filling raises concern for sinkholes and embankment erosion • Up to 6 inches of settlement occurred over a 500 feet reach at right abutment during high pool; additional settlement and limited height of the drain/filter zone and embankment materials causes concern for cracking that could lead to seepage erosion of the embankment core.	• Installation of flow-measuring devices to continuously measure discharge through abutment sandstone • Installed pins for measuring cracks in the tunnel liner • Orientation seminar with local emergency management officials • Surveillance and monitoring plan update to target activities specific to high risk concerns	• New instrumentation • Geologic modeling • Embankment drain modifications • Hydrologic adequacy evaluation • Riprap overlay

Dam Name	Dam Location	Physical Characteristics	Risk Evaluation Concerns	Current Actions	Possible Future Actions
Harlan County	Harlan County, Nebraska, near the communities of Republican City and Alma, Nebraska		• Tainter gate design methods did not include bearing friction in the structural design of the gate frames; the potential for gate seizure or failure is pronounced with increasing water load on the gates • The spillway stability remains a technical concern and does not meet current design standards, however the dam is not at risk of failure due to an earthquake • The current spillway was found to be hydrologically deficient; the Probable Maximum Flood would virtually eliminate the design freeboard that prevent embankment overtopping	• Update Harlan County's surveillance portion of the EAP • Replace dam monitoring instrumentation to more precisely predict dam performance • Install additional relief wells to further relieve foundation pressures in the area of concern • Tandem Balance Study to optimize water storage between Harlan and Reclamation reservoirs	• Conduct dam safety exercises with local emergency management agencies and responders • Inspection of the irrigation conduits and sluiceway gates
Pomme de Terre	Pomme de Terre River, approximately two miles south of Hermitage, Missouri in Hickory and Polk Counties	Rolled earth and rock fill embankment; main embankment is 4,630 feet long and 155 feet in height	• Stilling basin has severe concrete erosion; high flows could cause continued damage to the stilling basin and impact operations • Foundation or abutment seepage and piping are of concern; Piezometric data indicate possibility of a gradually deteriorating grout curtain • Rim dike would have stability issues under rapid drawdown after a spillway design flood event • Spillway could erode under very high flows	• Rehabilitation of the stilling basin	

Missouri is particularly concerned about the high hazard Clearwater Dam in Wayne County, which is currently part of a USACE major rehabilitation project. According to the Corps, Clearwater Dam has experienced seepage-related issues extending back to shortly after its completion in 1942. Various methods have been used over the years to remediate or reduce this problem. Nevertheless, the

problems have worsened and in January 2003, a sinkhole in the upstream face of the dam further called into question the integrity of the dam. The area most at risk should the dam fail extends from the dam downstream to Poplar Bluff (it is estimated that such an event could cause 369 deaths and $200 million in property damage). The major rehabilitation project on the Clearwater dam is scheduled to be completed in 2013.

Dams located outside of the State's boundaries could impact Missouri as well. Of particular concern is the Tuttle Creek Dam in Riley, Pottawatomie, and Marshall Counties in northeast Kansas on the Big Blue River, nine miles upstream from the confluence of the Blue and Kansas rivers. It is situated near the Humboldt fault line, which is associated with the Nemaha Uplift. Earthquake models show that the dam could be significantly damaged to the point that the lake could wash out the dam. Efforts are under way to shore up the dam to withstand a moderate to large earthquake. In the meantime, should this dam fail, floodwaters may travel east and impact Missouri.

The Gavins Point Dam, located on the Missouri River in South Dakota, is another dam outside of Missouri's boundaries that has the possibility of impacting the State in the case of a failure. There are a number of reports that focus on past and future spring pulse releases from this structure in addition to studies on possible water storage increases within the system. The USACE's Missouri River Master Manual provides a good starting point for additional information.

Past Occurrences

According to Stanford University's National Performance of Dams Program, there were 82 dam incidents in Missouri between 1975 and 2013. Of these 82 incidents, 17 (21 percent) of them were failures. The National Performance of Dams Program incident report database did not list any dam incidents in Missouri between 2001 and 2013; however there are two known incidents in 2005 and 2008 that have been added to this table (refer to Table 3.3.2d).

Table 3.3.2d Dam Incidents in Missouri, 1975-2001

NPDP ID	Dam Name	Incident Date	Incident Type	Dam Failure
MOS00014	Unnamed Dam (MOS00014)	1977	Inflow Flood - Hydrologic Event	No
MOS00013	Pinkston	1978	Piping	Yes
MO30474	Dresser No.4 Dam (Failed)	8/15/1975	Piping	Yes
MO30474	Dresser No.4 Dam (Failed)	8/15/1975	Piping	No
MO31374	Richardet Dam	Dec-85	Seepage; Embankment Slide	Yes
MO31923	Marschke Lake Dam	4/19/1988	Not Known	Yes
MOS00004	St. Joe State Park Sediment Impoundment	2/15/1990	Inflow Flood - Hydrologic Event; Inadequate Spillway Capacity	Yes
MO20145	Christiansen Lake Dam	May-90	Embankment Erosion	Yes
MO10620	Bullard Lake Dam	5/15/1990	Inflow Flood - Hydrologic Event	No
MO11224	Bass Lake Dam	5/15/1990	Inflow Flood - Hydrologic Event	No

NPDP ID	Dam Name	Incident Date	Incident Type	Dam Failure
MOS00006	Allen Dale Subdivision Dam	5/21/1990	Inflow Flood - Hydrologic Event	No
MO31849	Rogue Creek Upper Dam (Incomplete)	5/25/1990	Inflow Flood - Hydrologic Event	No
MO30923	Pinnacle Lake Dam	6/7/1990	Inflow Flood - Hydrologic Event	No
MO11005	Woodridge Lake Dam	6/8/1990	Embankment Erosion	No
MO12279	Hester Lake Dam	6/27/1990	Not Known	Yes
MO30951	Brushy Creek Tailings Dam	1/9/1991	Toe Berm Erosion	No
MO12279	Hester Lake Dam	4/9/1991	Piping	Yes
MO31915	Mcnulty Lake Dam	5/13/1991	Inflow Flood - Hydrologic Event	No
MO30098	Brays Lake Dam	5/13/1991	Inflow Flood - Hydrologic Event	No
MO10414	Lake Viking Dam	10/28/1991	Not Known	No
MO31725	Miller Lake Dam	4/2/1992	Embankment Slide	No
MOS00001	No Name (owned by Lonnie Hollaway)	5/25/1992	Embankment Slide	No
MO31988	ISP Minerals, Inc. Plant	6/3/1992	Not Known	Yes
MO31988	ISP Minerals, Inc. Plant	6/3/1992	Tailings Pile Failure	No
MOS00015	Unnamed Dam (MOS00015)	6/5/1992	Erosion	Yes
MO12370	Harrison County Lake	1/3/1993	Inflow Flood - Hydrologic Event	Yes
MO30541	Las Brisas Lake Dam	5/24/1993	Seepage; Embankment Erosion	No
MOS00002	Norman Swinney's Dam	5/26/1993	Inadequate Compaction	Yes
MO11260	Robbins Lake Dam	5/26/1993	Embankment Slide	No
MO10107	Stevens Lake Dam	Jun-93	Inflow Flood - Hydrologic Event	Yes
MO10660	City Of Higbee Dam	6/18/1993	Seepage	No
MO31526	Bockelman Lake Dam	Jul-93	Inflow Flood - Hydrologic Event	Yes
MO10154	Lake Marie Dam	7/8/1993	Embankment Erosion	No
MO10366	Trenton Lower Lake Dam	7/14/1993	Inflow Flood - Hydrologic Event	No
MO20166	Carp And Commandeer Dams	7/14/1993	Inflow Flood - Hydrologic Event	No
MO31452	Hidden Lake Dam	7/16/1993	Embankment Erosion	No
MO10414	Lake Viking Dam	7/22/1993	Inflow Flood - Hydrologic Event	No
MO10414	Lake Viking Dam	8/9/1993	Inflow Flood - Hydrologic Event	No

NPDP ID	Dam Name	Incident Date	Incident Type	Dam Failure
MO10366	Trenton Lower Lake Dam	8/10/1993	Inflow Flood - Hydrologic Event	No
MO12277	Mozingo Creek Dam	8/10/1993	Inflow Flood - Hydrologic Event	No
MO12234	F.E.M., Inc. Lake Dam	8/11/1993	Inflow Flood - Hydrologic Event	No
MO30832	Sunny Mount Dam	9/23/1993	Animal Attack	No
MO31996	Boyd Lake Dam	9/25/1993	Embankment Slide	Yes
MO32026	Freddies Lake Dam	9/26/1993	Inflow Flood - Hydrologic Event	Yes
MO10581	Lake Arrowhead Dam	10/5/1993	Inflow Flood - Hydrologic Event	No
MO31835	Lac Shayne Dam	10/7/1993	Embankment Slide	No
MO20036	Fellows Lake Dam	10/28/1993	Concrete Deterioration	No
MO10135	Holiday Acres Lake Dam	1/3/1994	Seepage; Embankment Slide	No
MO31422	Dresser #11 Tailings Pond Dam	2/17/1994	Concrete Deterioration	No
MO10044	Prairie Lee Lake Dam	4/22/1994	Embankment Slide	No
MO31743	Goose Creek Dam	4/27/1994	Concrete Deterioration	No
MOS00003	Bettison	5/26/1994	Embankment Slide	No
MO31846	Silver Creek Lake Dam	6/21/1994	Concrete Deterioration	No
MO30347	Seven Lakes #1	6/21/1994	Concrete Cracking	No
MO12277	Mozingo Creek Dam	7/7/1994	Inflow Flood - Hydrologic Event	No
MOS00007	Unnamed Dam	7/14/1994	Debris - Reservoir	No
MO20754	Shatto Lake Mill Dam	7/21/1994	Inflow Flood - Hydrologic Event	No
MO30347	Seven Lakes #1	8/24/1994	Embankment Slide	No
MOS00008	Unnamed Dam	8/30/1994	Seepage; Piping	No
MO10627	Nehai Tonkayea Lake Dam	11/14/1994	Embankment Slide	No
MO10581	Lake Arrowhead Dam	11/15/1994	Embankment Slide	No
MO10660	City Of Higbee Dam	3/23/1995	Embankment Slide	No
MO30572	Lake Arrowhead Dam	5/17/1995	Inflow Flood - Hydrologic Event	No
MO20237	Sunny Shores Dam	6/21/1995	Seepage	No
MO10262	Bowling Green #1 Dam	6/26/1995	Seepage; Piping	No
MOS00009	Unnamed Dam	8/24/1995	Inflow Flood - Hydrologic Event	No
MO31960	Owl Creek Estates Dam No. 3	8/31/1995	Embankment Slide	No
MO20447	Wells Lake Dam	12/7/1995	Cracks/Tree Growth	No

NPDP ID	Dam Name	Incident Date	Incident Type	Dam Failure
MO10627	Nehai Tonkayea Lake Dam	12/10/1995	Embankment Slide	No
MO30057	Iron Mountain Lake Dam	4/22/1996	Embankment Erosion	No
MO32038	Block Lake Dam	4/28/1996	Inflow Flood - Hydrologic Event	No
MO10153	Macon Lake Dam	5/7/1996	Inflow Flood - Hydrologic Event	No
MO30452	Tamarack Dam	5/31/1996	Inflow Flood - Hydrologic Event	No
MO11258	102 Riv Trib Wtrshd Strctr Lt-36	12/4/1996	Debris - Reservoir	No
MO20164	Lake Venita Dam	2/21/1997	Seepage; Piping	Yes
MO20805	Schacktenberg Company Dam	2/26/1997	Animal Attack	No
MO30217	Carp Lake Dam	3/2/1997	Embankment Slide	No
MOS00011	Unnamed Dam	3/5/1997	Inflow Flood - Hydrologic Event	No
MOS00010	Unnamed Dam (Schacktenberg Company Dam?)	8/2/1997	Seepage; Piping	No
MO11241	Lake Flamingo Dam	6/6/2001	Seepage/Piping	No
MOS00012	T-69 Watershed Site	8/22/2001	Concrete Deterioration	No
MO11526	Junior Lake Dam	11/14/2001	Swallow Hole	No
N/A	Taum Sauk	12/14/2005	Suspected Instrumentation Failure	Yes
N/A	Moon Valley Lake Dam	03/17/2008	Unknown	Yes

Source: Stanford University's National Performance of Dams Program, http://npdp.stanford.edu/index.html

On December 14, 2005, the Taum Sauk reservoir dam owned by AmerenUE of St. Louis failed (see Figure 3.3.2.7 on the following page). A 600-foot breech in the northwest side of the retention facility released 1.5 billion gallons of stored water into the Johnson Shut-Ins State Park in 10 minutes. The waters destroyed the park and the park superintendent's house and swept the superintendent's family out of their house. All five family members survived. The lower reservoir was overtopped by the flow of the east fork of the Black River. As a precautionary measure, the City of Lesterville (Reynolds County) evacuated 100-150 people to higher ground. If the dam had failed during the summer months, during the park's peak use, it is likely that many lives would have been lost.

Figure 3.3.2.7 - 2005 Failure of AmerenUE's Taum Sauk Reservoir Dam

Source: State of Missouri Attorney General's Office

The 2011 floods in Missouri led to the Corps of Engineers having to release record levels of water through the Gavin point Dam. This release did cause downstream flooding; however, the reservoirs upstream were at 100% capacity. The difficult choice to release so much water was supported by local officials. In Wyatt, MO the Corps had to breach the Bird's Point Levee late at night, in order to reduce pressure on a floodwall protecting the town.

Measure of Probability and Severity

Probability: Low
Severity: Moderate

Probability

For the 26-year period from 1975 to 2001 for which dam failure statistics are available, 17 dam failures were recorded. This does not include the Taum Sauk failure in 2005 or the Moon Valley Lake Dam failure in 2008 since the comprehensive data collected by Stanford University was not updated past 2001. According to this data, the annual probability calculates to a 65% probability in any given year for at least one dam failure event somewhere in the State of Missouri. However, with over 5,000 dams in the State, this translates to an overall low probability per dam structure.

Severity

For purposes of discussing severity of the dam failure hazard, this plan will refer to the downstream hazard classification system utilized by the State of Missouri Department of Natural Resources Dam and Reservoir Safety Program as set forth by the Dam and Reservoir Safety Council. (See page 3.377 in section 3.5.2 for dam hazard classification criteria) There is a separate downstream hazard potential classification system utilized by the National Inventory of Dams. However, since this is a state mitigation plan, the state-defined classifications will be discussed.

When considering permits for dam construction, the Missouri Dam Reservoir Safety Program officials consider the three classes based on the downstream environment zone or the area downstream from a dam that would be affected by inundation in the event the dam failed. The three classes based on the downstream environment are identified in the State Regulated Dams section above and associated inspection frequencies are set forth in the Rules and Regulations of the Missouri Dam and Reservoir Safety Council (also available here).

Impact of the Hazard

When a dam fails, the stored water can be suddenly released and have catastrophic effects on life and property downstream. Homes, bridges, and roads can be demolished in minutes. The failure of the Buffalo Creek Dam in 1972 in West Virginia killed 125 people. The 2005 collapse of the Taum Sauk upper reservoir destroyed the house of the superintendent of DNR's Johnsons Shut-ins State Park in Reynolds County. The family of five was rescued by the Lesterville Volunteer Fire Department. DNR is depending on AmerenUE to provide the funds to restore the park to its original condition. At least 26 recorded dam failures have occurred in 20 Missouri counties since the turn of the 20th century. Fortunately, only one drowning has been associated with a dam failure in the State, and there has been little consequence to property.

Residents near a class 1 or class 2 hazard dam should become familiar with the dam's emergency action plans, if available. Emergency plans written for dams include procedures for notification and coordination with local law enforcement and other governmental agencies, information on the potential inundation area, plans for warning and evacuation, and procedures for making emergency repairs.
The information in Table 3.3.2e is from the Impact Analysis of Potential for Detrimental Impacts of Hazards completed for the Emergency Management Accreditation Program.

Table 3.3.2e EMAP Impact Analysis: Dam Failure

Subject	Detrimental Impacts
Health and Safety of Persons in the Area at Time of Incident	Localized impact expected to be severe for inundation area and moderate to light for other adversely affected areas.
Health and Safety of Personnel Responding to the Incident	Localized impact expected to limit damage to personnel in the inundation area at the time of the incident.
Continuity of Operations	Damage to facilities/personnel in the area of the incident may require temporary relocation of some operations.
Property, Facilities, and Infrastructure	Localized impact to facilities and infrastructure in the inundation area of the incident. Some severe damage possible.
Delivery of Services	Localized disruption of roads and/or utilities may postpone delivery of some services.
The Environment	Localized impact expected to be severe for inundation area and moderate to light for other adversely affected areas.
Economic and Financial Condition	Local economy and finances adversely affected, possibly for an extended period of time, depending on damage and length of investigation.
Regulatory and Contractual Obligations	Regulatory waivers may be needed locally. Fulfillment of some contracts may be difficult. Impact may reduce deliveries.
Reputation of or Confidence in the Entity	Localized impact expected to primarily adversely affect dam owner and local entities.

Synopsis

Missouri's percentage of high hazard dams in the DNR inventory puts the State at about the national average for that category. However, if development occurs downstream of dams the percentage of high hazard dams will increase. Additionally, the probability of dam failure increases as many of the smaller and privately owned dams continue to deteriorate without the benefit of further regulation or improvements. Based on this information, the State rates the overall probability of dam failure as low and the severity as moderate.

Dam breaks are caused most often by failure of the structure itself. However, flooding is the most common hazard associated with dam failure. Prolonged rains and flooding can saturate earthen dams, for example, producing much the same breaching effect as occurs with earthen levees. Flooding can also result in overtopping of dams when the spillway and reservoir storage capacities are exceeded. A large slide may develop in either the upstream or downstream slope of the embankment and threaten to release the impounded water. Complete structural collapse can occur, especially as a result of an earthquake.

Actual dam failure can result not only in loss of life, but also considerable loss of capital investment, loss of income, and property damage. Loss of the reservoir itself can cause hardship for those dependent on it for their livelihood or water supply. For additional information on vulnerability to dam failure, see Section 3.5.2.

3.3.3 Levee Failure

Description of Hazard

Levees are earth embankments constructed along rivers and coastlines to protect adjacent lands from flooding. Floodwalls are concrete structures, often components of levee systems, designed for urban areas where there is insufficient room for earthen levees. When levees and floodwalls and their appurtenant structures are stressed beyond their capabilities to withstand floods, levee failure can result in loss of life and injuries as well as damages to property, the environment, and the economy. Levees are usually engineered to withstand a flood with a computed risk of occurrence. In Missouri, there are an estimated 1,926 miles of levees, many of which were largely constructed to protect agricultural land and are not built to design standards established to protect people and property. Their presence can, in some cases, generate a false sense of security. If a larger flood occurs, then that structure will likely be compromised. In the event of a levee failure, the water behind it can be released as flash flood. Failed levees can create floods that are catastrophic to life and property in part because of the tremendous energy of the released water. Figure 3.3.3.1 depicts a levee failure that occurred in 2008 in Lincoln County, MO.

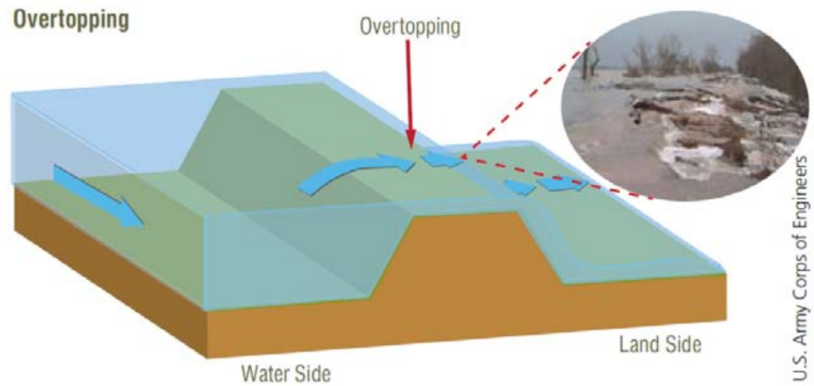
Figure 3.3.3.1 - 2008 Levee Failure in Missouri

Source: Jocelyn Augustino, FEMA, Elsberry, MO, June 20, 2008 -- A levee in the Elsberry levee district breaks, flooding farmland and houses in the area.

For purposes of this discussion, it is necessary to define "levee failure." Levee failure traditionally refers to both *overtopping* and *breach* of a levee, as defined in FEMA's Publication "So You Live Behind a Levee" (http://content.asce.org/ASCELeveeGuide.html).

Overtopping occurs when floodwaters exceed the height of a levee and flow over its crown. As the water passes over the top, it may erode the levee, worsening the flooding and potentially causing an opening, or breach, in the levee. (Figure 3.3.3.2)

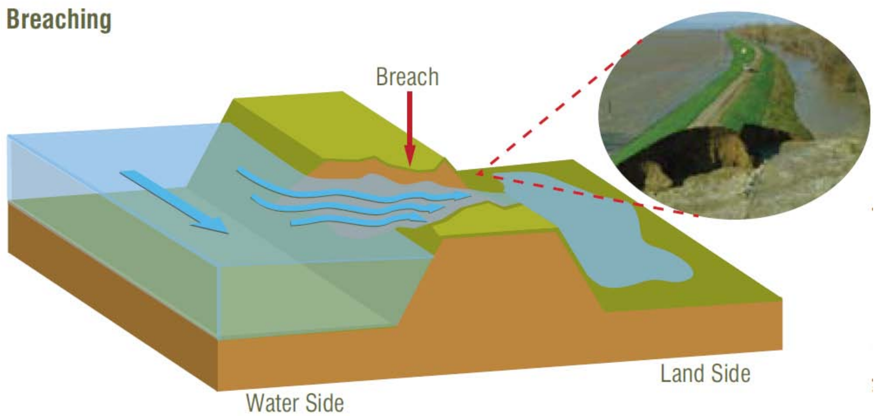
Figure 3.3.3.2 - Overtopping: When a Flood Is Too Big



A levee breach occurs when part of a levee gives way, creating an opening through which floodwaters may pass (Figure 3.3.3.3). A breach may occur gradually or suddenly. The most dangerous breaches happen quickly during periods of high water. The resulting torrent can quickly swamp a large area behind the failed levee with little or no warning.

Earthen levees can be damaged in several ways. For instance, strong river currents and waves can erode the surface. Debris and ice carried by floodwaters—and even large objects such as boats or barges—can collide with and gouge the levee. Trees growing on a levee can blow over, leaving a hole where the root wad and soil used to be. Burrowing animals can create holes that enable water to pass through a levee. If severe enough, any of these situations can lead to a zone of weakness that could cause a levee breach. In seismically active areas, earthquakes and ground shaking can cause a loss of soil strength, weakening a levee and possibly resulting in failure. Seismic activity can also cause levees to slide or slump, both of which can lead to failure.

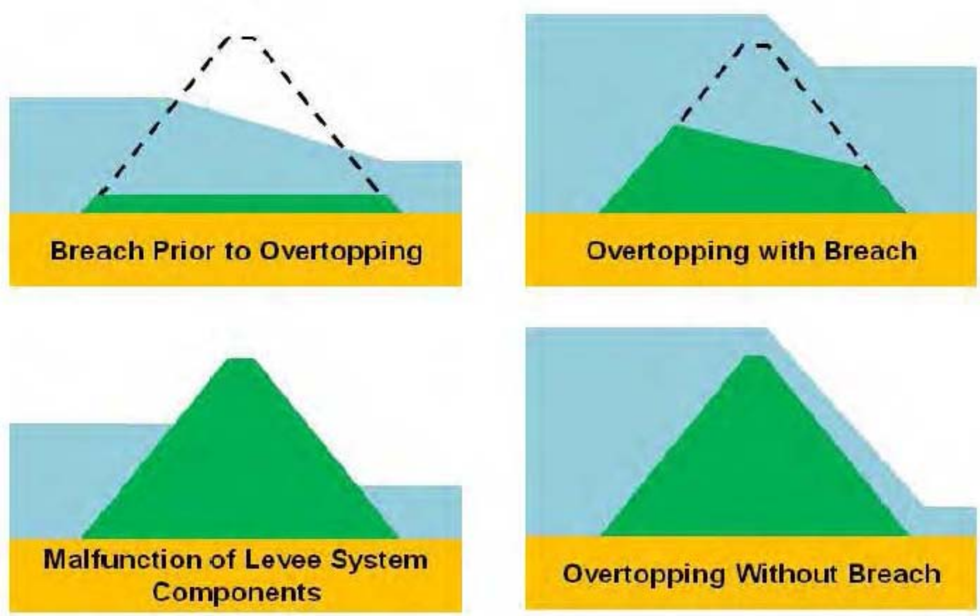
Figure 3.3.3.3 - Breaching: When a Levee Gives Way



The 2013 draft USACE report "Hazard Mitigation Actions in Relation to State Hazard Mitigation Plans – Kansas and Missouri" presents a more refined classification scheme of levee inundation risk. In this report, a total of four scenarios are defined as posing inundation risk to the area landward of a levee system. Furthermore, the term "levee failure" was qualified as "non desired performance." The four inundation scenarios, as shown on Figure 3.3.3.4, are:

- Overtopping without breach
- Breach due to overtopping
- Breach before overtopping
- Non-performance of a component (such as a gate) that lead to flooding of the protected area.

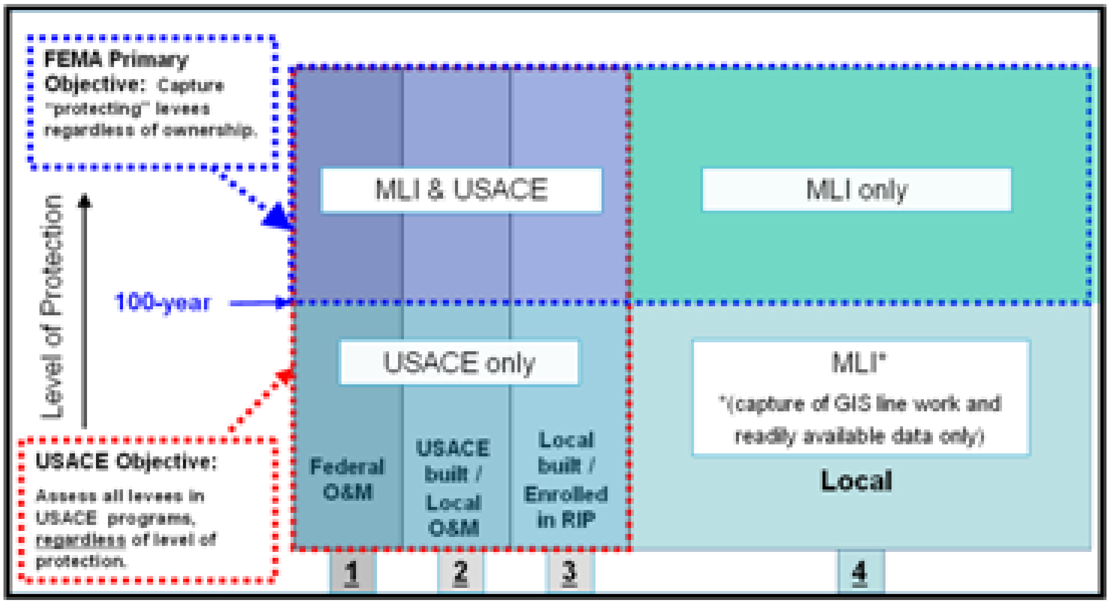
Figure 3.3.3.4 - Inundation Scenarios



Levee Inventories in Missouri

There are two concurrent nation-wide levee inventory development efforts, one led by the United State Army Corps of Engineers (USACE) and one led by Federal Emergency Management Agency (FEMA). The National Levee Database (NLD), developed by USACE, captures all USACE related levee projects, regardless design levels of protection, while Midterm Levee Inventory (MLI), developed by FEMA, captures all levee data (USACE and non-USACE) but primarily focus on levees that provide 1% annual-chance flood protection on FEMA Flood Insurance Rate Maps (FIRMs). Figure 3.3.3.5 summarizes the universe of levees inventoried by each of the two federal agencies. As of February 2013, both the FEMA MLI inventory and the USACE NLD inventory efforts are considered complete for the State of Missouri.

Figure 3.3.3.5 - Concurrent Levee Inventory Efforts by USACE and FEMA



For purposes of the levee failure hazard profile in this plan, levees in Missouri will be discussed in three categories:

1) Levees in the USACE Levee Safety Program.
2) Levees Recognized on FEMA Digital Flood Insurance Rate Maps (DFIRMs) as Providing Protection from the 1% Annual Chance Flood.
3) All other known levees not in the USACE Levee Safety Program or Recognized as Providing Protection from the 1% Annual Chance Flood.

Levees in the USACE Levee Safety Program:

In Missouri, there are currently 159 levee systems in the USACE Levee Safety Program. Of those, 23 are considered to be designed to provide protection from the 100-year flood. An additional 7 are designed to provide protection from the 500-year flood. The remaining levees provide protection against lower level flooding that occurs more frequently than the 1% annual chance flood (100-year flood).

According to the latest system inspection report from the USACE NLD, there are 4 levee systems within the USACE levee safety program in the state of Missouri that received an unacceptable rating from routine maintenance inspections conducted since Feb. 1, 2007. These levee systems that received an unacceptable rating are shown in Table 3.3.3a.

Table 3.3.3a Missouri Levee Projects

System Name	County	Sponsor(s)	Last Routine Inspection Date	Leveed Area Acreage
MRLS 497-L(1)	Holt County	Forest City Levee District Of Holt County Missouri	12-Apr-11	219.16
MRLS 497-L(2)	Holt County	Forest City Levee District Of Holt County Missouri	12-Apr-11	6521.36

System Name	County	Sponsor(s)	Last Routine Inspection Date	Leveed Area Acreage
Reorganized Butler County Drainage District No. 7	Butler County	-	18-Jun-08	10471.97
Elk Chute Levee System	Dunklin County, Pemiscot County	Elk Chute Dd	14-Sep-10	44280.26

Source: USACE NLD; http://nld.usace.army.mil/egis/f?p=471:58:994716546449901::NO

An unacceptable rating means a project has one or more deficient conditions that can be reasonably foreseen to prevent the project from functioning as designed, intended, or required. This information reflects a snapshot in time. It is dynamic and subject to change as projects are re-inspected, owners correct deficiencies and new data becomes available.

Levees Recognized through the Map Modernization Initiative on FEMA Digital Flood Insurance Rate Maps (DFIRMs) as Providing Protection from the 1% Annual Chance Flood:

Many levees shown on effective FIRMs were mapped in the 1970s and 1980s, and have never been remapped by FEMA. Prior to 1986, levees were shown on FIRMs as providing protection from the base flood (accredited) when they were designed and constructed in accordance with sound engineering practices. Since 1986, levees have been accredited on FIRMs only when they meet the requirements of 44 CFR 65.10 "Mapping Areas Protected by Levee Systems," including certification by a registered professional engineer or a Federal agency with responsibility for levee design.

Levees that do not meet the requirements of 44 CFR 65.10 cannot be accredited on a FIRM. Furthermore, areas behind the levee and at risk to base flood inundation are mapped as high risk areas subject to FEMA's minimum floodplain management regulations and mandatory flood insurance purchase requirement.

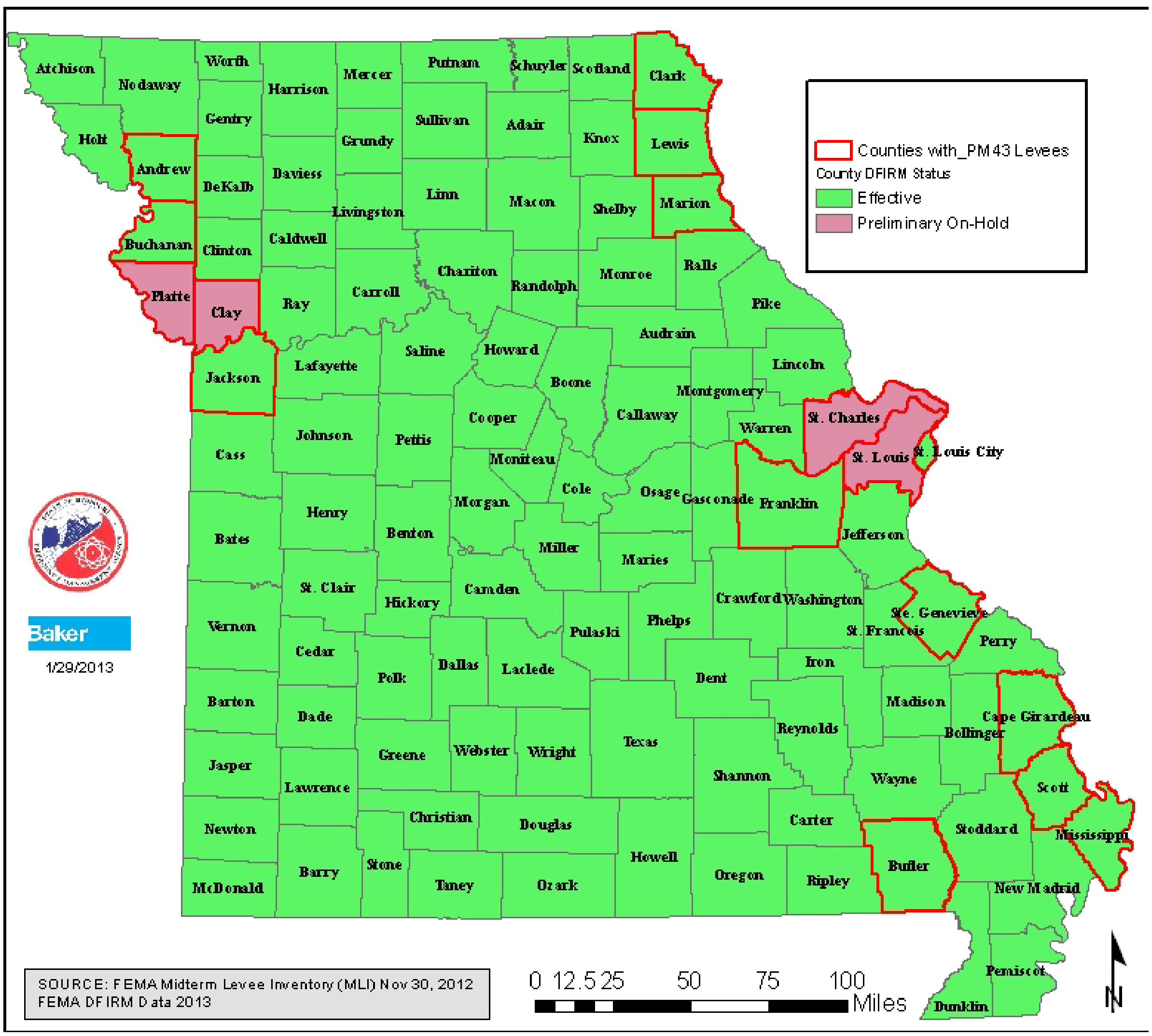
In 2004, as it initiated work under the Flood Map Modernization Initiative (Map Mod), FEMA determined that analysis of the role of levees in flood risk reduction would be an important part of the mapping efforts. A report issued in 2005 noted that the status of the Nation's levees was not well understood and the condition of many levees and floodwalls had not been assessed since their original inclusion in the NFIP. As a result, FEMA established Procedure Memorandom 34 and 43 to address the status of existing levees. As DFIRMs are developed, levees fall under one of the three following categories:

1) Accredited Levee - With the except of areas of residual flooding (interior drainage), if the data and documentation specified in 44 CFR 65.10 is readily available and provided to FEMA, the area behind the levee will be mapped as a moderate-risk area. There is no mandatory flood insurance purchase requirement in a moderate-risk area, but flood insurance is strongly recommended.
2) Provisionally Accredited Levee (PAL) - If data and documentation is not readily available, and no known deficiency precludes meeting requirements of 44 CFR 65.10, FEMA can allow the party seeking recognition up to two years to compile and submit full documentation to show compliance with 44 CFR 65.10. During this two-year period of provisional accreditation, the area behind the levee will be mapped as moderate-risk with no mandatory flood insurance purchase requirement.

3) De-Accredited Levees – If the information established under 44 CFR 65.10 is not readily available and provided to FEMA, and the levee is not eligible for the PAL designation, the levee will be de-accredited by FEMA. The area behind the levee will be mapped as a high-risk area subject to mandatory flood insurance purchase requirement.
4) Never Accredited Levees - levees that have never been shown on a FIRM as meeting the criteria of 44CFR65.10.

Of the 115 Missouri counties that are in various stages of receiving Digital Flood Insurance Rate Maps under the Map Modernization Initiative, 47 of those counties have levees; of the 47 counties, 17 are impacted by levees addressed under PM34 and 43, namely, those that are accredited, provisionally accredited, or de-accredited. Figure 3.3.3.6 shows these counties (outlined in red).

Figure 3.3.3.6 - Missouri DFIRM Status (as of February 2013)



Source; U.S. Department of Homeland Security, FEMA Region VII, February1, 2013

Table 3.3.3b provides the accreditation status of levees in these 17 counties as of December 2009. The table distinguishes between USACE program levees and non USACE program levees.

Table 3.3.3b Levee Accreditation Status in DFIRM Counties in Missouri

County Name	Primary Community	Levee Owner	USACE Program Levee	Levee Status
Andrew	Amazonia	Amazonia Levee District	Yes	De-accredited
Buchanan	Buchanan County Unincorporated Areas	Halls Levee District	Yes	PAL
Buchanan	Buchanan County Unincorporated Areas	Halls Levee District	Yes	PAL
Buchanan	St. Joseph & Buchanan County Unincorporated Areas	South St. Joseph Drainage District	Yes	PAL
Butler	Poplar Bluff	Butler County Drainage District No. 12	Yes	PAL
Butler	Unincorporated Areas	Private - N/A	No	Not PAL Eligible
Butler	Unincorporated Areas	Private - N/A	No	Not PAL Eligible
Butler	Unincorporated Areas	Private - N/A	No	Not PAL Eligible
Butler	Unincorporated Areas	Private - N/A	No	Not PAL Eligible
Butler	Butler County Unincorporated Areas	N/A	No	Not PAL Eligible
Butler	Butler County Unincorporated Areas	N/A	No	Not PAL Eligible
Cape Girardeau	Cape Girardeau City	City of Cape Girardeau	Yes	PAL
Clark	Alexandria	Des Moines & Mississippi Levee District #1	Yes	PAL
Clay	Kansas City, MO	Birmingham Drainage District	Yes	PAL
Clay	Kansas City, MO ; North Kansas City	City of Kansas City, MO	Yes	Accredited
Clay	North Kansas City	North Kansas City Levee District	Yes	PAL
Franklin	New Haven	City of New Haven	Yes	PAL
Jackson	Kansas City MO	City of Kansas City MO	Yes	PAL
Jackson	Jackson County Unincorporated Areas	Atherton Levee District	Yes	PAL
Jackson	Jackson County Unincorporated Areas	Atherton-Blue Mills Levee District	Yes	PAL
Jackson	Kansas City MO	GSA	No	Accredited
Jackson	Levasy		No	Not PAL Eligible
Lewis	Canton	City of Canton	Yes	PAL
Marion	Hannibal	City of Hannibal	No	Accredited
Marion	Marion County Unincorporated Areas	South River Drainage District	Yes	PAL

County Name	Primary Community	Levee Owner	USACE Program Levee	Levee Status
Marion	Marion County Unincorporated Areas	South River Drainage District	Yes	PAL
Marion	Marion County Unincorporated Areas	City of Fabius	No	Accredited
Marion	Marion County Unincorporated Areas	City of Fabius	No	Accredited
Marion	Marion County Unincorporated Areas	City of Fabius	No	Accredited
Marion	Marion County Unincorporated Areas	City of Fabius	No	Accredited
Marion	Marion County Unincorporated Areas	City of Fabius	No	Accredited
Marion	Marion County Unincorporated Areas	City of Fabius	No	Accredited
Marion	Marion County Unincorporated Areas	City of Fabius	No	Accredited
Platte	Platte County Unincorporated Areas	Waldron Levee District	Yes	PAL
Platte	Platte County Unincorporated Areas	Farley-Beverly Levee District	Yes	PAL
Platte	Riverside	Riverside-Quindaro Bend Levee District	Yes	PAL
Platte	Riverside	Riverside-Quindaro Bend Levee District	Yes	PAL
Scott	Scott County Unincorporated Areas	Little River Drainage District	Yes	Accredited
St. Charles	St. Peters	St. Peters Dardenne	No	Accredited
St. Charles	Unincorporated Areas	St Charles County	No	De-accredited
St. Charles	Unincorporated Areas	St Charles County	No	De-accredited
St. Louis	Chesterfield; St. Louis County Unincorporated Areas	Chesterfield Monarch	No	Accredited
St. Louis	Maryland Heights; Bridgeton; Unincorporated Areas	Earth City	No	Accredited
St. Louis	Bridgeton	Missouri Bottoms	No	Not PAL Eligible
St. Louis	Maryland Heights	Riverport Levee District	No	Accredited
St. Louis	Maryland Heights; Chesterfield	Howard Bend	No	Accredited
Ste. Genevieve	St. Genevieve City	St. Genevieve County Levee District No. 3	Yes	Accredited

Source: Federal Emergency Management Agency, as of February 2013.

All other known levees not in the USACE Levee Safety Program or Recognized as Providing Protection from the 1% Annual Chance Flood:

There are also other levees throughout the State that are intended to mitigate low-level flooding and/or protect agricultural land that are not in the USACE Levee Safety Program nor recognized on FEMA FIRMs. These levees may provide a false sense of security to residents. Information about these levees is very limited.

Historical Statistics

Table 3.3.3c, below, provides a history of levee damage for the lower Missouri River for selected levee districts from 1942 through 1993.

Table 3.3.3c History of Levee Damage in Missouri, 1942-1993

Levee District (Area) Name	Damage Years
Mittler et al	’45, ’46, ’52, ’53 ’58, ’66, ’73, ’82, ’86, ‘93
Darst Bottoms	’44, ’50, ’58 ’60, ’61, ’73, ’86 ‘93
Labadie Bottoms	’42, ’47, ’51, ’58, 66, ’73, ’86, ‘93
Pinckney-Peers	’42, 44, ’48, ’51, ’73, ’86, ‘93
Berger Bottoms	‘42, ‘44, ‘48, ‘51, ‘57, ‘61, ’73, ’86, ‘93
Overton Bottoms	’42, ’47, ’48, ’51, ’57, ’65, ’73, ’82, ’86, ‘93
Lisbon Bottoms	’43, ’44, ’48, ’52, ’59, ’60, ’67. ’69, ’73, ’79, ’82, ’86, ‘93
Cambridge	’82, ’83, ’84, ’85, ‘93
Rhoades Island	’61, ’73, ’74, ’82, ’83, ’84, ’86, ‘93
Miami-DeWitt	’43, ’47, ’51, ’67, ‘93

Source: Preliminary Report of the Scientific Assessment and Strategy Team, 1994; http://desastres.usac.edu.gt/documentos/pdf/eng/doc5646/doc5646-8a.pdf

Flood of 1993

In 1993, the Midwest Flood brought issues related to levees to the forefront. The flood approached or exceeded the 100-year threshold on most major rivers and resulted in overtopping or failure of large numbers of levees, most of them agricultural levees that provided various levels of damage/risk reduction. As a result of this flooding, 840 of Missouri's estimated 1,456 levees were damaged (http://www.sej.org/publications/tipsheet/levee-threats-gaining-attention).

Although only a few of the levee systems that were credited as providing 100-year protection were overtopped or failed, several levee systems protecting major urban areas, including parts of the City of St. Louis, were threatened. Had the flood been larger, these levee systems could also have been overtopped or failed. The single most costly levee failure during the Midwest Flood was the Monarch-Chesterfield Levee at Chesterfield, Missouri. This levee was an agricultural levee that had been upgraded during the early 1980s and was credited by FEMA as providing protection from the 100-year flood. Once the levee was credited, industrial and commercial development occurred. On July 30, an area of some 4,700 acres occupied by office and industrial parks, a large general aviation airport owned by St. Louis County government and a five-mile stretch of Interstate 64 disappeared under 10 feet of water. When floodwaters threatened the levee, most businesses bought flood insurance. When the levee failed, more

than $13 million in claims were paid. This translated to 5 percent of the total claims for the entire Midwest Flood. This levee has since been rebuilt and upgraded to provide 500-year flood protection. Because the levee break was in the upstream portion of the valley contained by the Monarch Levee, the floodwaters were very slow to drain out of that basin even as the level of the river dropped. Flood damage was estimated at more than $320 million in 2006 dollars.

Table 3.3.3d provides the number of failed or overtopped federal and non-federal levees in each USACE District during the 1993 flood event throughout the Midwest. Please note, these levee failure statistics are for the entire Midwest region impacted by the 1993 floods, not just the State of Missouri.

Table 3.3.3d Number of Failed or Overtopped Federal and Non-Federal Levees by USACE District—1993 Midwest Floods

USACE District	Federal	Non-Federal
St. Paul	1 of 32	2 of 92
Rock Island	12 of 73	19 of 185
St. Louis	12 of 42	39 of 47
Kansas City	6 of 48	810 of 810
Omaha	9 of 31	173 of 210
Totals	40 of 226	1043 of 1345

Source: http://www.nwrfc.noaa.gov/floods/papers/oh_2/great.htm

According to the Preliminary report of the Scientific Assessment and Strategy Team which was formed after the 1993 floods, approximately 5 to 7 percent of the floodplain (13,000 to 18,000 acres) was substantially damaged as a result of the levee breaches during the 1993 flood within the reach from Glasgow, Missouri to St. Louis, Missouri (about 225 river miles). Eyewitness accounts indicate that the majority of levee breaches were caused by overtopping, subsequent incision by gullies, and rapid flood-flow erosion. However, levee failures may have also been caused by underflow and piping beneath the levees, and by interflow piping within the levee structure itself.

2007 Flooding

According to a CBS news report, at least 20 levees were overtopped as floodwaters made their way down Missouri streams and rivers. Nine levee breaks inundated the town of Big Lake, Missouri in Holt County. The broken levees included five on the Missouri River and four smaller levees along the Tarkio River and the Tarkio Creek (none of them operated by USACE. Levee breaks or overtopping were also reported in the following counties: Ray, Carroll, Clay, Chariton, Lafayette, Jackson, Saline and Platte.

2008 Flooding

March—Levee failures occurred on the Black River near Poplar Bluff, in Butler County, and in Stoddard County (SEMA Situation Report, March 18, 2008).

June—Several cities were wholly or partially flooded by levee failures or overtopping, including Clarksville, Winfield, Foley, and St. Charles. According to a news report, the Winfield case was especially illustrative of the fragility of some levees in the protection system, as the flood waters broke through a 3 inch tunnel dug by a muskrat and poured water out under pressure like a fire house. Many volunteers and National Guard troops were able to keep most other levees intact.

2011 Flooding

April— On April 26, 2011, the same levee that failed in the 2008 flooding near Poplar Bluff, Butler County, failed again in at least four locations along a two-mile stretch along the Black River (CNN Report, April 26, 2008). The threat of levee failure at another location prompted the evacuation of 1,000 people. This particular levee failed a federal inspection in 2008, receiving an "unacceptable" rating from the USACE.

Measure of Probability and Severity

100-year Event
Probability: High
Severity: High

500-year Event
Probability: Moderate
Severity: High

Probability
Given the numerous levee systems constructed along the main stems and tributaries of Missouri River and Colorado River, the State of Missouri is highly susceptible to catastrophic levee failure and/or overtopping. Not counting the great flood of 1993, for the 70-year period from 1942 to 2012 for which levee failure statistics are available, over 100 levee failures/overtoppings were recorded. In the flood of 1993 alone, 840, or over 55% of the levees in the State sustained significant damages. This translates to an overall high probability of 1% annual chance flood levee failures in any given year. The probability of a 0.2% annual chance flood levee failure has been defined as Moderate as part of this Plan update.

Severity
According to the MLI, levees in the State of Missouri that are accredited against the 0.2 % and 1% annual chance flood provide protection for close to 2,200 square miles of land. The multitude of privately-constructed and maintained levees provide protection for an even greater expanse of agricultural land. Should major flood events similar to the 1993 flood strike, the severity of damage to human lives and properties from all levee failures is expected to be high. While the US Army Corps of Engineers have done major levee reconstruction for levees that are in the PL84-99 program following the 1993 flood, proper inspection, diligent maintenance, and timely repair are key to controlling the severity of levee failure damage in the event of another catastrophic flood.

Impact of the Hazard

The impact of levee failure during a flooding event can be very similar to a dam failure in that the velocity of the water caused by sudden release as a result of levee breach can result in a flood surge or flood wave that can cause catastrophic damages (see Table 3.5a). If the levee is overtopped as a result of flood waters in excess of the levee design, impacts are similar to flood impacts.

Table 3.3.3e EMAP Impact Analysis: Levee Failure

Subject	Detrimental Impacts
Health and Safety of Persons in the Area at Time of Incident	Localized impact expected to be severe for inundation area and moderate to light for other adversely affected areas.
Health and Safety of Personnel Responding to the Incident	Localized impact expected to limit damage to personnel in the inundation area at the time of the incident.
Continuity of Operations	Damage to facilities/personnel in the area of the incident may require temporary relocation of some operations.
Property, Facilities, and Infrastructure	Localized impact to facilities and infrastructure in the inundation area of the incident. Some severe damage possible.
Delivery of Services	Localized disruption of roads and/or utilities may postpone delivery of some services.
The Environment	Localized impact expected to be severe for inundation area and moderate to light for other adversely affected areas.
Economic and Financial Condition	Local economy and finances adversely affected, possibly for an extended period of time, depending on damage and length of investigation.
Regulatory and Contractual Obligations	Regulatory waivers may be needed locally. Fulfillment of some contracts may be difficult. Impact may reduce deliveries.
Reputation of or Confidence in the Entity	Localized impact expected to adversely affect confidence in local, state, and federal government, regardless of the levee owner.

Synopsis

Flooding is the most common hazard associated with levee failure, breach or overtopping. Levee failure, breach, or overtopping can result not only in loss of life, but also considerable loss of capital investment, loss of income, and property damage.

For additional information on vulnerability and loss estimates to levee failure, see Section 3.5.1.

3.3.4 Earthquake

Description of Hazard

Earthquakes are defined as shifts in the earth's crust causing the surface to become unstable. This instability can manifest itself in intensity from slight tremors to large shocks. The duration can be from a few seconds up to five minutes. The period of tremors (and shocks) can last up to several months. The larger shocks can cause ground failure, landslides, liquefaction, uplifts, and sand blows.

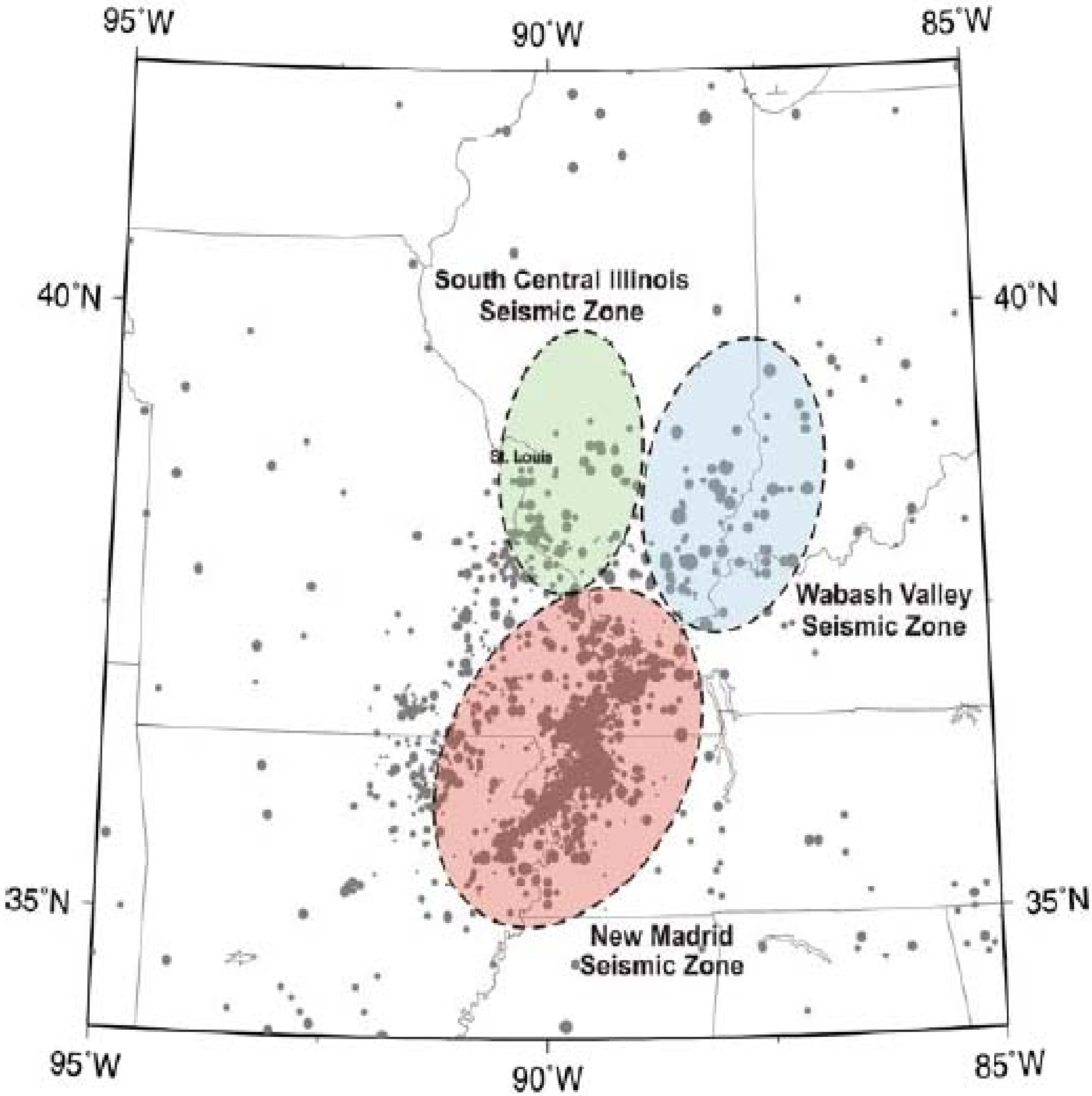
The earth's crust is made up of gigantic plates, commonly referred to as tectonic plates. These plates form what is known as the lithosphere, which varies in thickness from 6.5 miles (beneath oceans) to 40 miles (beneath mountain ranges), and has an average thickness of 20 miles. These plates "float" over a partly melted layer of crust called the asthenosphere. These plates are in constant motion, and areas where one plate joins another are referred to as "plate boundaries." Areas where the plates are moving toward each other are called convergent plate boundaries, areas where they are moving away from each other are called divergent plate boundaries, and areas where they are neither moving away nor towards each other are called transform boundaries. The San Andreas Fault in California is one such transform boundary where the Pacific Plate is moving to the north while the North American Plate is moving to the west.

Plate movements release built-up energy in the form of earthquakes, tremors, and volcanic activity. Fault lines such as the San Andreas come all the way to the surface and can be readily seen and identified. Some fault lines do not come all the way to the surface, yet all faults store and release energy when they move. Many of the faults in the central United States are characterized this way.

Subterranean faults, faults that do not make it to the surface, were formed many millions of years ago on or near the surface of the earth. Subsequent to that time, these ancient faults subsided, while the adjacent areas were pushed up. As this fault zone (also known as a rift) sank, sediments filled in the lower areas. Under pressure, sediments hardened into limestone, sandstone, and shale, thus burying the rifts. With the pressure on the North Atlantic Ridge affecting the eastern side of the North American Plate, and the movements along the San Andreas Fault by the Pacific Plate, one such rift system in the Mississippi embayment has reactivated. This particular rift system is now called the Reelfoot Rift.

Eight earthquake seismic zones are located in the central United States, two of which are located in Missouri. The most active zone is the New Madrid Seismic Zone, which is also the most active seismic area in the United States east of the Rocky Mountains and, according to the U.S. Geological Survey. The New Madrid Zone is by some measures as high a risk for tremors as seismic zones in California. It runs from northern Arkansas through southeast Missouri and western Tennessee and Kentucky to the Illinois side of the Ohio River Valley.

Figure 3.3.4.1 - New Madrid, South Central Illinois, and Wabash Valley Seismic Zones



Source: Rogers, Karadeniz, and Cramer (in press 2007)

The southeastern (Bootheel) section of Missouri is most susceptible to earthquakes because it overlies the New Madrid Seismic Zone. It is at risk to strong ground motions and has a high potential for soil liquefaction due to the presence of sandy, loosely consolidated sediments and a high water table. The immediate vicinity of the Ozarks is also at risk from earthquakes in the New Madrid Seismic Zone because, like in the Bootheel, subsurface conditions of the Mississippi and Missouri river valleys tend to amplify earthquake ground shaking. Earthquake hazards in the western part of the State also exist because of the historical earthquakes in eastern Kansas and Nebraska. No area of Missouri is immune from the danger of earthquakes. Minor, but potentially damaging, earthquakes can occur anywhere in the State.

In addition to the New Madrid Seismic Zone, other seismic zones that affect Missourians include the Wabash Valley Seismic Zone, the South Central Illinois Seismic Zone, and the Nemaha Uplift. The Wabash and Illinois seismic zones are not as active as the New Madrid Seismic Zone based on microseismic activity, but they are considered capable of producing earthquakes in the range of M 6.0 to 6.8. An earthquake of this magnitude on the South Central Illinois Seismic Zone could potentially cause more damage to the St. Louis metropolitan area than a New Madrid Seismic Zone event. This is because St. Louis metropolitan area is closer to the South Central Illinois Seismic Zone than it is to the New Madrid Zone. The Nemaha Uplift is of concern to Missourians because it runs parallel to the Missouri/Kansas border from Lincoln, Nebraska, to Oklahoma City, Oklahoma. Earthquakes from the Nemaha Uplift are not as severe as those associated with the historic New Madrid Seismic Zone.

Large earthquakes in Missouri could trigger additional hazards such as soil liquefaction, lateral spreading, landslides, and sinkhole collapse (specifically in the karst topography present in much of southeast Missouri). Liquefaction is a site soil response to strong earthquake ground motion. Strong earthquake waves cause water pressure to increase within sandy soils; force sand grains apart, and causes the material to behave as a dense liquid. Sandblows form in the areas where liquefied sand is overlain by heavier clay rich silts, causing a geyser-like eruption of sand onto the land surface. Liquefaction causes land to lose its load-bearing capacity, which can lead to differential settlement and associated building foundation failures. Lateral spreading can occur even on gentle slopes and seriously damage buried utilities and road networks. Landslides could be triggered in steep slopes and road cuts through unstable geologic materials, potentially damaging and closing roads and railroads. Earthquake shaking will exacerbate existing problems and cause even more slides where none have existed before. It is possible that housing developments on certain shale bedrock units could be affected by landslides with potentially catastrophic results.

Historical Statistics

Small earthquakes occur often in Missouri. About 200 are detected every year in the New Madrid Seismic Zone. Most can only be detected by sensitive instruments, but southeast Missouri experiences an earthquake once or twice every 18 months that is strong enough to crack plaster in buildings.

The most severe earthquakes occurred in the New Madrid Seismic Zone during a period between December 16, 1811, and March 12, 1812. The earthquakes on December 16, 1811, and February 7, 1812, rank number seven and nine respectively among the United States' largest earthquakes. An engineer in Louisville, Kentucky, counted over 1,850 shocks during this time, including three earthquakes of magnitude greater than 8.3 (Richter magnitude). The shocks from these earthquakes could be easily felt as far away as Detroit, Michigan, and Charleston, South Carolina. The area between the St. Francois River and Mississippi River south of New Madrid to Marked Tree, Arkansas, showed numerous sand blows from liquefaction.

Areas uplifted as well as subsided (dropped) along the Mississippi River. For instance, the area around Tiptonville, Tennessee, formed a dome (uplift of several yards). Immediately adjacent to the Tiptonville Dome, an area subsided to form a lake 18 miles long and 5 miles wide. It is now known as Reelfoot Lake and is a tourist and recreation area. Ground failure and landslides were apparent throughout the bluffs (Chickasaw Bluffs) alongside the Mississippi River in Kentucky and Tennessee. Many fissures were made throughout the region, and one local observer recorded that the earth seemed to be rolling in waves a few feet in height. These swells would burst, leaving wide and long fissures. The damage to the area was so severe that Congress passed, and President James Madison signed into law, disaster relief assistance

to the effected population, giving government lands in other territories to people wanting to move out of the area.

The following is excerpted directly from Carl A. von Hake's "Missouri Earthquake History" in Earthquake Information Bulletin, Volume 6, Number 3, May–June 1974:

> Whatever the seismic history of the region may have been before the first Europeans arrived, after December 16, 1811, there could be no doubt about the area's potential to generate severe earthquakes. On that date, shortly after 2 AM, the first tremor of the most violent series of earthquakes in the United States history struck southeast Missouri. In the small town of New Madrid, about 180 miles south of St. Louis, residents were aroused from their sleep by the rocking of their cabins, the cracking of timbers, the clatter of breaking dishes and tumbling furniture, the rattling of falling chimneys, and the crashing of falling trees. A terrifying roaring noise was created as the earthquake waves swept across the ground. Large fissures suddenly opened and swallowed large quantities of river and marsh water. As the fissures closed again, great volumes of mud and sand were ejected along with the water.
>
> The earthquake generated great waves on the Mississippi River that overwhelmed many boats and washed others high upon the shore. The waves broke off thousands of trees and carried them into the river. High river banks caved in, sand bars gave way, and entire islands disappeared. The violence of the earthquake was manifested by great topographic changes that affected an area of 30,000 to 50,000 square miles.
>
> On January 23, 1812, a second major shock, seemingly more violent than the first, occurred. A third great earthquake, perhaps the most severe of the series, struck on February 7, 1812.
>
> The three main shocks probably reached intensity XII, the maximum on the Modified Mercalli scale (defined on page 3.418), although it is difficult to assign intensities, due to the scarcity of settlements at the time. Aftershocks continued to be felt for several years after the initial tremor. Later evidence indicates that the epicenter of the first earthquake (December 16, 1811) was probably in northeast Arkansas. Based on historical accounts, the epicenter of the February 7, 1812, shocks was probably close to the town of New Madrid.
>
> Although the death toll from the 1811-12 series of earthquakes has never been tabulated, the loss of life was very slight. It is likely that if at the time of the earthquakes the New Madrid area had been as heavily populated as at present, thousands of persons would have perished. The main shocks were felt over an area covering at least 2,000,000 square miles. Chimneys were knocked down in Cincinnati, Ohio, and bricks were reported to have fallen from chimneys in Georgia and South

Carolina. The first shock was felt distinctly in Washington, D.C., 700 miles away, and people there were frightened badly. Other points that reported feeling this earthquake included New Orleans, 500 miles away; Detroit, 600 miles away; and Boston, 1,100 miles away.

The New Madrid seismic zone has experienced numerous earthquakes since the 1811-12 series, and at least 35 shocks of intensity V or greater have been recorded in Missouri since 1811. Numerous earthquakes originating outside of the State's boundaries have also affected Missouri. Five of the strongest earthquakes that have affected Missouri since the 1811-12 series are described below.

On January 4, 1843, a severe earthquake in the New Madrid area cracked chimneys and walls at Memphis, Tennessee. One building reportedly collapsed. The earth sank at some places near New Madrid; there was an unverified report that two hunters were drowned during the formation of a lake. The total felt area included at least 400,000 square miles.

The October 31, 1895, earthquake near Charleston, Missouri, probably ranks second in intensity to the 1811-12 series. Every building in the commercial area of Charleston was damaged. Cairo, Illinois, and Memphis, Tennessee, also suffered significant damage. Near Charleston, 4 acres of ground sank and a lake was formed. The shock was felt over all or portions of 23 states and at some places in Canada.
A moderate earthquake on April 9, 1917, in the Ste. Genevieve–St. Mary's area was reportedly felt over a 518,000 square kilometer area from Kansas to Ohio and Wisconsin to Mississippi. In the epicentral area people ran into the street, windows were broken, and plaster cracked. A second shock of lesser intensity was felt in the southern part of the area.

The small railroad town of Rodney, Missouri, experienced a strong earthquake on August 19, 1934. At nearby Charleston, windows were broken, chimneys were overthrown or damaged, and articles were knocked from shelves. Similar effects were observed at Cairo, Mounds and Mound City, Illinois, and at Wickliff, Kentucky. The area of destructive intensity included more than 230 square miles.

The November 9, 1968, earthquake centered in southern Illinois was the strongest in the central United States since 1895. The magnitude 5.5 shock caused moderate damage to chimneys and walls at Hermann, St. Charles, St. Louis, and Sikeston, Missouri. The felt areas include all or portions of 23 states.

Most recently along the Nemaha Seismic Zone, an earthquake of 3.1 Richter magnitude occurred on March 31, 1993, close to the Cooper Nuclear Power Station in Brownville, Nebraska. Another 3.1 occurred on March 23, 2007, near Effingham, Kansas. No damage resulted from either event; however,

the earthquake was felt across the Missouri River into Missouri. See Table 3.3.4a for a list of moderate/large earthquakes in the Central United States.

Table 3.3.4a Moderate/Large Earthquakes in the Central United States

Date	Locality	Magnitude	Maximum Intensity	Source Zone
December 16, 1811	New Madrid, Missouri	8.6	XII	New Madrid Fault
January 23, 1812	New Madrid, Missouri	8.0	XII	New Madrid Fault
February 7, 1812	New Madrid, Missouri	8.0	XII	New Madrid Fault
June 9, 1838	Southern Illinois	5.7	VI	Illinois Basin
January 4, 1843	Western Tennessee	6.3	VIII	New Madrid Fault
Unknown, 1860	Central Minnesota	5.0	Unknown	Colorado Lineament
August. 17, 1865	Southeastern Missouri	5.3	VII	New Madrid Fault
April 24, 1867	Lawrence, Kansas	5.1	VII	Nemaha Uplift
June 18, 1875	Western Ohio	5.3	VII	Cincinnati Arch
November 15, 1877	Eastern Nebraska	5.0	VII	Nemaha Uplift
October 22, 1882	Arkansas, Texas	5.5	VI–VII	Ouchita, Wichita Fault
July 26, 1891	Illinois, Indiana	5.9	VI	Wabash Valley Fault
October 31, 1895	Charleston, Missouri	6.7	VIII	New Madrid Fault
May 26, 1909	Illinois	5.1	VII	Cincinnati Arch
April 9, 1917	Eastern Missouri	5.0	VI	St. Francois Uplift
March 8, 1937	Western Ohio	5.0	VII–VIII	Cincinnati Arch
April 9, 1952	Enid, Oklahoma	5.1	VII	Nemaha Uplift
November 9, 1968	South Central Illinois	5.5	VII	Wabash Valley Fault
March 24, 1976	Marked Tree, Arkansas	5.0	V–VI	New Madrid Fault
July 27, 1980	North Central Kentucky	5.2	VII	Cincinnati Arch
January 31, 1986	Anna, Ohio	5.0	VI	Cincinnati Arch
June 9, 1987	Lawrenceville, Illinois	5.2	V–VI	Wabash Valley Fault
September 26, 1990	Chaffee, Missouri	3.0	IV–V	New Madrid Fault
May 3, 1991	Risco, Missouri	4.6	IV–V	New Madrid Fault
June 26, 2000	Harrison, Arkansas	3.9	VIII	Ouchita, Wichita Fault
December 7, 2000	Evansville, Indiana	3.9	V	Wabash Valley Fault
May 4, 2001	Conway, Arkansas	4.4	VI	Ouchita, Wichita Fault
February 8, 2002	Lewton, Oklahoma	3.9	V	Nemaha Uplift
June 18, 2002	Evansville, Indiana	4.6	VI	Wabash Valley Fault
November 3, 2002	O'Neill, Nebraska	4.3	V	Nemaha Uplift
June 6, 2003	Cairo, Illinois	4.0	VI	New Madrid Fault
August 16, 2003	West Plains, Missouri	4.0	V	New Madrid Fault
June 15, 2004	Sikeston, Missouri	3.7	V	New Madrid Fault

Date	Locality	Magnitude	Maximum Intensity	Source Zone
June 28, 2004	Ottawa, Illinois	4.2	VI	Illinois Basin
September 17, 2004	Middlesboro, Kentucky	3.7	V	New Madrid Fault
February 10, 2005	Blytheville, Arkansas	4.1	V	New Madrid Fault
May 1, 2005	Blytheville, Arkansas	4.1	V	New Madrid Fault
June 2, 2005	Dyersburg, Tennessee	4.0	IV	New Madrid Fault
August 24, 2005	Greeneville, Tennessee	3.7	IV	New Madrid Fault
January 2, 2006	Harrisburg, Illinois	3.6	II–III	Wabash Valley Fault
October 18, 2006	Lilborn, Missouri	3.4	IV	New Madrid Fault
April 18, 2008	Gards Point, IL	5.2	VII	Wabash Valley Fault
April 18, 2008	Ogden, IL	4.6	VI	Wabash Valley Fault
April 21, 2008	Gards Point, IL	4.0	V	Wabash Valley Fault
April 21, 2008	Ogden, IL	4.2	V	Wabash Valley Fault

Source: State Hazard Analysis, October 2009

According to the USDA Risk Management Agency, insured crop losses throughout the State of Missouri as a result of earthquakes for the eleven year period of 1998 – 2008 totaled $4,082 in only Lafayette County. A detailed listing of insured crop losses by crop, county, and, year for insured crop losses is provided at the following link: USDA Risk Management Agency Crop Claims Data..

Measure of Probability and Severity

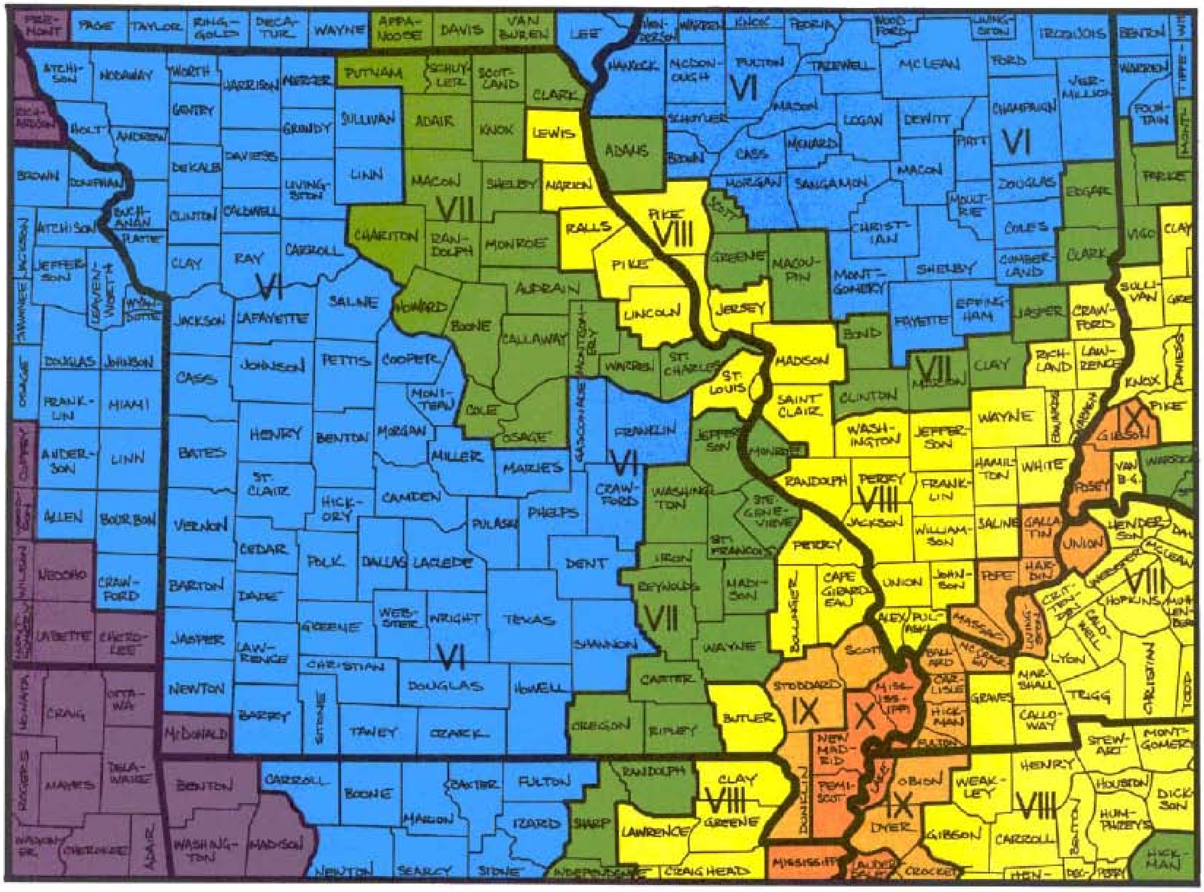
Probability: High

Severity: High

The Center for Earthquake Research and Information (CERI) at the University of Memphis has computed conditional probabilities of a magnitude 6.0 earthquake in the New Madrid seismic zone. According to a fact sheet prepared by SEMA in 2003, the probability for a magnitude 6.0 to 7.5 or greater earthquake along the New Madrid Fault is 25 to 40 percent over the next 50 years. With approximately 12.5 million people living in the area, steps are being taken to reduce related hazards to citizens and property in the area. The probability of an earthquake increases with each day, which makes it difficult to rate. Based on the information from CERI, the probability of an earthquake is rated as high, and the severity is rated as high.

The map in Figure 3.3.4.2 shows the highest projected Modified Mercalli intensities by county from a potential magnitude 7.6 earthquake whose epicenter could be anywhere along the length of the New Madrid Seismic Zone. The secondary maps show the same regional intensities for a 6.7 and an 8.6 earthquake, respectively. Figure 3.3.4.3 describes the projected earthquake intensities for each level of the Modified Mercalli Intensity Scale.

Figure 3.3.4.2 - Projected Earthquake Intensities

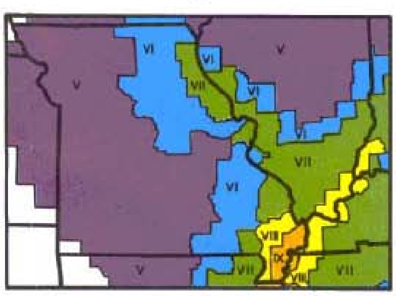


This map shows the highest projected Modified Mercalli intensities by county from a potential magnitude – 7.6 earthquake whose epicenter could be anywhere along the length of the New Madrid seismic zone.

6.7

7.6

8.6



This map shows the highest projected Modified Mercalli intensities by county from a potential magnitude – 6.7 earthquake whose epicenter could be anywhere along the length of the New Madrid seismic zone.

This map shows the highest projected Modified Mercalli intensities by county from a potential magnitude – 8.6 earthquake whose epicenter could be anywhere along the length of the New Madrid seismic zone.

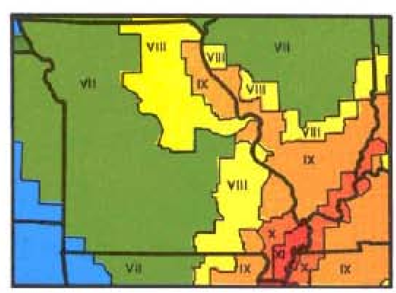


Figure 3.3.4.3 - Modified Mercalli Intensity Scale

I People do not feel any Earth movement.

II A few people might notice movement.

III Many people indoors feel movement. Hanging objects swing.

IV Most people indoors feel movement. Dishes, windows, and doors rattle. Walls and frames of structures creak. Liquids in open vessels are slightly disturbed. Parked cars rock.

V Almost everyone feels movement. Most people are awakened. Doors swing open or closed. Dishes are broken. Pictures on the wall move. Windows crack in some cases. Small objects move or are turned over. Liquids might spill out of open containers.

VI Everyone feels movement. Poorly built buildings are damaged slightly. Considerable quantities of dishes and glassware, and some windows are broken. People have trouble walking. Pictures fall off walls. Objects fall from shelves. Plaster in walls might crack. Some furniture is overturned. Small bells in churches, chapels and schools ring.

VII People have difficulty standing. Considerable damage in poorly built or badly designed buildings, adobe houses, old walls, spires and others. Damage is slight to moderate in well-built buildings. Numerous windows are broken. Weak chimneys break at roof lines. Cornices from towers and high buildings fall. Loose bricks fall from buildings. Heavy furniture is overturned and damaged. Some sand and gravel stream banks cave in.

VIII Drivers have trouble steering. Poorly built structures suffer severe damage. Ordinary substantial buildings partially collapse. Damage slight in structures especially built to withstand earthquakes. Tree branches break. Houses not bolted down might shift on their foundations. Tall structures such as towers and chimneys might twist and fall. Temporary or permanent changes in springs and wells. Sand and mud is ejected in small amounts.

IX Most buildings suffer damage. Houses that are not bolted down move off their foundations. Some underground pipes are broken. The ground cracks conspicuously. Reservoirs suffer severe damage.

X Well-built wooden structures are severely damaged and some destroyed. Most masonry and frame structures are destroyed, including their foundations. Some bridges are destroyed. Dams are seriously damaged. Large landslides occur. Water is thrown on the banks of canals, rivers, and lakes. Railroad tracks are bent slightly. Cracks are opened in cement pavements and asphalt road surfaces.

XI Few if any masonry structures remain standing. Large, well-built bridges are destroyed. Wood frame structures are severely damaged, especially near epicenters. Buried pipelines are rendered completely useless. Railroad tracks are badly bent. Water mixed with sand, and mud is ejected in large amounts.

XII Damage is total, and nearly all works of construction are damaged greatly or destroyed. Objects are thrown into the air. The ground moves in waves or ripples. Large amounts of rock may move. Lakes are dammed, waterfalls formed and rivers are deflected.

Intensity is a numerical index describing the effects of an earthquake on the surface of the Earth, on man, and on structures built by man. The intensities shown in these maps are the highest likely under the most adverse geologic conditions. There will actually be a range in intensities within any small area such as a town or county, with the highest intensity generally occurring at only a few sites. Earthquakes of all three magnitudes represented in these maps occurred during the 1811 - 1812 "New Madrid earthquakes." The isoseismal patterns shown here, however, were simulated based on actual patterns of somewhat smaller but damaging earthquakes that occurred in the New Madrid seismic zone in 1843 and 1895.

Prepared and distributed by
THE MISSOURI STATE
EMERGENCY MANAGEMENT AGENCY
P.O. BOX 116
JEFFERSON CITY, MO 65102
Telephone: 573-526-9100

Impact of the Hazard

The impacts of earthquakes on Missouri can be significant. The New Madrid earthquakes of 1811–1812 are among the largest that have occurred on the North American continent. Although losses were limited because of the sparse population of the time, many Native Americans died and property was damaged to the point that resettlement became a national policy.

The most important direct earthquake hazard is ground shaking. Ground shaking affects structures close to the earthquake epicenter but can also affect those at great distances, particularly where thick clay-rich soils can amplify ground motions. Certain types of buildings are more vulnerable to ground shaking than others. Unreinforced masonry structures, tall structures without adequate lateral resistance, and poorly maintained structures are specifically susceptible to large earthquakes.

According to DNR's Division of Geology and Land Survey, damage from earthquakes in the New Madrid Seismic Zone will vary depending on the earthquake magnitude, the character of the land, and the degree of urbanization. The Bootheel area is predominantly rural with scattered small to medium-sized towns. Damage to the land could be extensive and significantly affect the area's agricultural base. The more distant, densely populated urban area of St. Louis is not likely to have damage to the land, but its huge stock of structures and their contents could receive significant damage from shaking and earthquake-triggered landslides and sinkhole collapse. Shaking would be most severe to development built on thick, clay-rich soils. Roads and railroads in southeast Missouri and Saint Louis area could be severely damaged by earthquake triggered slope failures, rockfalls, and liquefaction.

During most earthquakes, liquefaction happens in relatively small isolated patches. The New Madrid Seismic Zone is unique because it is in a vast area with ideal conditions for liquefaction. Liquefaction could be an enormous problem in a large earthquake and even for a magnitude 6–6.5 earthquake occurring in a portion of the Bootheel. Infrastructure (roads, bridges, power lines, gas lines, water lines, petroleum pipelines, telephone lines, ports, etc.) will be severely damaged and disrupted by liquefaction. This will likely make it difficult to perform rescue and recovery operations because these infrastructure facilities will be needed but may take a long time to repair.

Several studies indicate the need to prepare for earthquakes, as scholars estimate that the New Madrid Seismic Zone has the capability of generating Mercalli intensities of X (ten) in southeast Missouri. The late Dr. Otto Nuttli of St. Louis University stated in his book, *The Effects of Earthquakes in the Central United States*, that surface-wave magnitudes of 7.6 (Richter) would create the largest possible earthquake that could occur anywhere along the New Madrid Seismic Zone in the near future. Information on preparedness and predictions related to the New Madrid Seismic Zone is provided on the U.S. Geological Survey Earthquake Hazards Program web site at www.usgs.gov/hazards, and the Center for Earthquake Research and Information web site at www.ceri.memphis.edu/usgs.

Another report, *Impact of Earthquakes on the Central USA,* dated September 2008 presents the findings of a two-year study on the impact of a 7.7 magnitude earthquake on states in the New Madrid Seismic Zone (NMSZ). The study was conducted for FEMA by the Mid-America Earthquake (MAE) Center at the University of Illinois in partnership with the Central United States Earthquake Consortium (CUSEC), the U.S. Geological Survey (USGS), USACE, and George Washington University's Institute for Crisis, Disaster and Risk Management. It is primarily intended to provide scientific data upon which to base response and recovery planning for the devastating earthquakes that have long been predicted for the New Madrid region, which includes areas of Alabama, Arkansas, Illinois, Indiana, Kentucky, Mississippi,

Missouri and Tennessee. The study is also available for download at https://www.ideals.illinois.edu/handle/2142/8971.

The information in Table 3.3.4b is from the Impact Analysis of Potential for Detrimental Impacts of Hazards done for the Emergency Management Accreditation Program.

Table 3.3.4b EMAP Impact Analysis: Earthquakes

Subject	Detrimental Impacts
Health and Safety of Persons in the Area at Time of Incident	Adverse impact expected to be severe for unprotected personnel and moderate to light for protected personnel.
Health and Safety of Personnel Responding to the Incident	Adverse impact expected to be severe for unprotected personnel and moderate to light for protected personnel.
Continuity of Operations	Damage to facilities/personnel in the area of the incident may require relocation of operations and lines of succession execution.
Property, Facilities, and Infrastructure	Damage to facilities and infrastructure in the area of the incident may be extensive for facilities, people, infrastructure, and HazMat.
Delivery of Services	Disruption of lines of communication and destruction of facilities may extensively postpone delivery of services.
The Environment	May cause extensive damage, creating denial or delays in the use of some areas. Remediation needed.
Economic and Financial Condition	Local economy and finances adversely affected, possibly for an extended period of time.
Regulatory and Contractual Obligations	Regulatory waivers may be needed. Fulfillment of contracts may be difficult. Demands may overload ability to deliver.
Reputation of or Confidence in the Entity	Ability to respond and recover may be questioned and challenged if planning, response, and recovery not timely and effective.

Synopsis

The chances of an earthquake occurring increases each day. Energy from the movement of the North American tectonic plate continues to build up along the New Madrid and Nemaha Seismic Zones and their subsidiary systems. The State has suffered earthquakes in the past and will have another in the future. The exact time and place is unknown, but the State is overdue for a moderate earthquake. The earthquake may affect the citizens of Missouri and surrounding states. Earthquakes also have secondary effects such as fires, building collapses, utility disruptions, dam failures, flooding, hazardous material releases, environmental impacts, and economic disruptions or losses.

For additional information on vulnerability to Earthquake, see Section 3.5.4.

3.3.5 Land Subsidence / Sinkholes

Description of Hazard

Land subsidence is sinking of the earth's surface due to the movement of earth materials below the surface. This sinking can be sudden or gradual and is generally attributed to the removal of subsurface water or the draining of organic soils (AGS, 2012). In Missouri, subsidence is primarily associated with sinkholes but they can also occur from void space left by mining, and natural caves (Van Dyke, 2003).

Sinkholes

In the case of sinkholes, the rock below the surface is limestone, carbonate rock, salt beds, or some other rock that can be naturally dissolved by circulating groundwater. As the rock dissolves, spaces and caverns form, and ultimately the land above the spaces collapse. In Missouri, sinkhole problems are usually a result of surface materials above openings into bedrock caves eroding and collapsing into the cave opening. These collapses are called "cover collapses" and geologic information can be applied to predict the general regions where collapse will occur. Sinkholes range in size from several square yards to hundreds of acres and may be quite shallow or hundreds of feet deep (Kaufmann, 2007).

Figure 3.3.5.1 - Sinkhole Collapse in Nixa, Missouri (Gouzie, 2006)

Sinkhole formation is most intense where the bedrock is most soluble and has been exposed to extended periods of weathering and where surficial materials are between 40 and 80 feet in thickness and are composed of relict bedrock structure residuum containing clays with low dry densities. Bedrock faulting also contributes to deep weathering, cave formation, and sinkhole formation.

According to the U.S. Geological Survey, the most damage from sinkholes tends to occur in Florida, Texas, Alabama, Missouri, Kentucky, Tennessee, and Pennsylvania (USGS, 2013). Fifty-nine percent of

Missouri is underlain by thick, carbonate rock that makes Missouri vulnerable to sinkholes (Missouri DNR, 2013). Sinkholes occur in Missouri on a fairly frequent basis Most of Missouri's sinkholes occur naturally in the State's karst regions (areas with soluble bedrock). They are a common geologic hazard in southern Missouri, but also occur in the central and northeastern parts of the State in vulnerability overview). While most of them are from natural causes, others are a result of human activities. Triggering factors include activities that alter the natural hydrologic conditions, the collapse of storm sewers or other abandoned and forgotten manmade voids, and subsurface mining (Veni, 2001).

Mining

Mining activity in Missouri has been occurring since the early 1740s. Missouri has a vast amount of minerals hidden beneath the surface. Minerals founds include lead, vast supplies of zinc, copper, nickel, and cobalt, tripoli, stone, clay, industrial sand, lime, barite, and coal were extracted from Missouri's mines (Missouri DNR, 2013). (See the Vulnerability Section for Missouri mining map)

Figure 3.3.5.2 - Ore Cart at Bonne Terre, Missouri (lissalou66, 2009)

Natural Caves

A cave is a natural underground opening large enough to explore, therefore, a cave may be a rock shelter, or a pit opening in the bottom of a sinkhole, or a cavernous, many-roomed passage that extends deep into the earth. Missouri is known for their more than 6,000 natural caves through the State (Missouri DNR, 2013). (See the Vulnerability Section for Missouri caves map)

Figure 3.3.5.3 - Stalactites on the roof of Meramac caves (Marcin Wichary, 2008)

Historical Statistics

Sinkholes are a regular occurrence in Missouri, but rarely are the events of any significance. However, there have been occasional damages related to sinkholes. The following events are from Jim Vandike's "That Sinking Feeling—A Void, a Collapse" in the Spring/Summer 2003 issue of Missouri's Department of Natural Resources' Missouri Resources:

In 1948, a well-drilling rig was constructing a mineral-test hole on the St. Francis River floodplain in St. Francois County when sinkholes began developing around the rig. By the time the well was cased, there were approximately 20 sinkholes up to 90 feet long and 20 feet wide within 500 feet of the rig.

A lake in northern Howell County was built in the 1960s on a tributary of the Eleven Point River in an area characterized by deeply weathered bedrock, losing streams, and sinkholes. A sinkhole formed in the floor of the lake and quickly drained it. Efforts to stop the leak failed and the lake will only hold water for short periods following heavy rainfall.

Sinkhole collapses have occurred in sewage lagoons at several southern Missouri towns including West Plains and Republic. In most instances, the lagoons were abandoned and new lagoons were constructed on better sites or the towns switched wastewater-treatment methods.

Mining-related collapses have occurred in the Joplin area where lead and zinc were once mined; southeastern Missouri (Washington, Iron, St. Francois, and Reynolds Counties), where lead has been mined since the 1700s; northern and western Missouri (and part of St. Louis) where coal was mined underground prior to the 1940s; and throughout Missouri where underground limestone quarries are common.

Other more recent events include the following:

- August 6, 2012, a sinkhole caused a road to collapse near Springfield-Branson National Airport. A water main snapped when the concrete collapsed. The hole likely formed after heavy rains.
- In 2009 a sinkhole approximately 70' by 30' at the bottom of a rain runoff area in Battlefield, Greene County, had to be patched as it threatened a city sewer lift station. (News-Leader, 2009) In August 2006, a sinkhole collapse in the City of Nixa in Christian County severely destroyed a residence and vehicle and threatened adjacent homes and city utilities (Anderson, 2008).
- In February 2005, a sinkhole appeared in a pasture in Barry County and grew to be the size of a football field (Groundspeak, 2013).
- In June 2004, a sinkhole drained 23-acre Lake Chesterfield in St. Louis County (Associated Press, 2004).

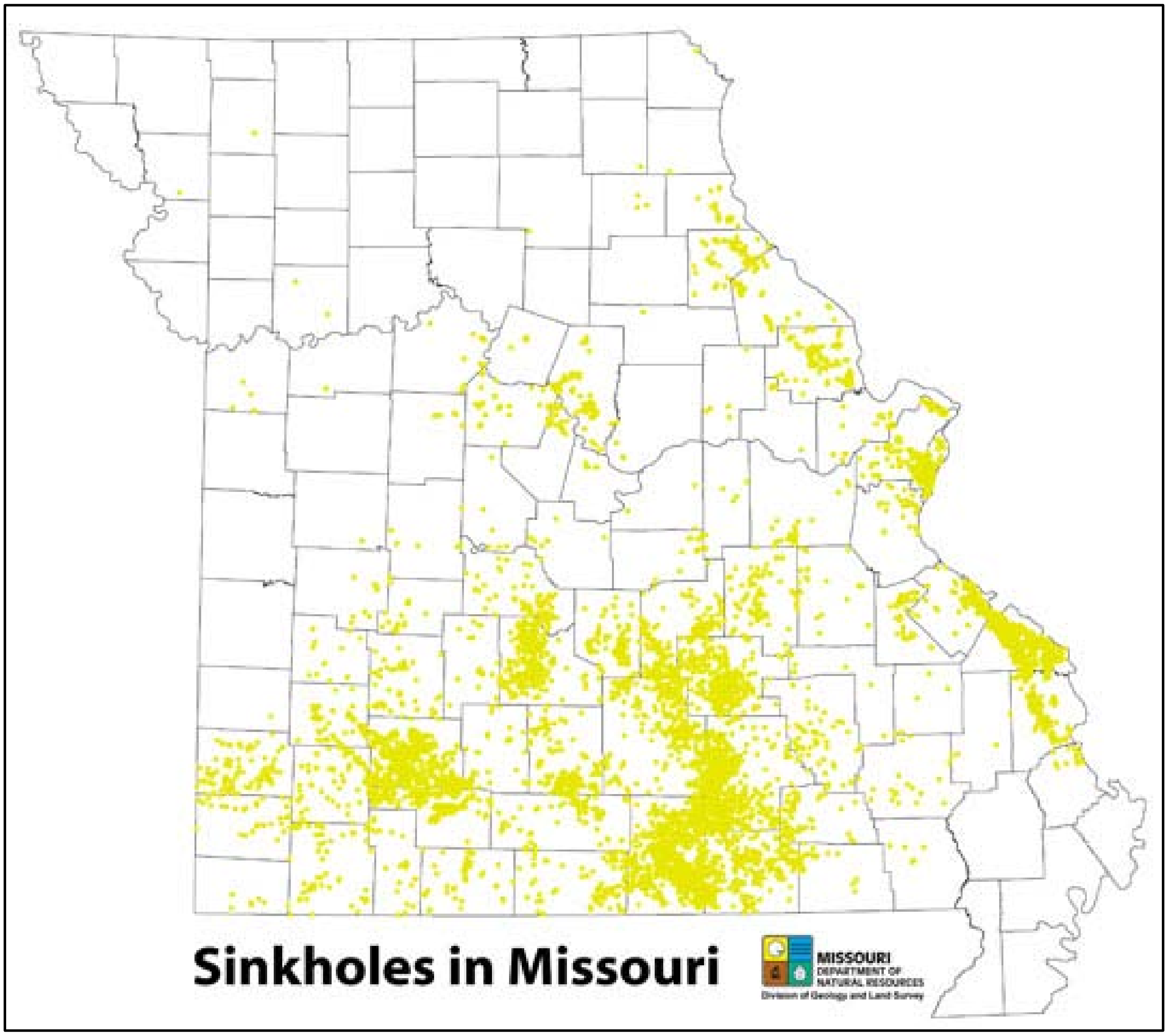
Measure of Probability and Severity

Probability: High

Severity: Low

Sinkhole location data is collected by the Missouri Department of Natural Resources (DNR) and is illustrated in Figure 3.3.5.4. The map shows sinkholes that have been reported to the MO Geological Survey Program or are on U.S. Geological Survey Topographic Maps. Other sinkholes may exist that have not been reported to the program and are not illustrated below. Sinkholes occur much more frequently in the southern portion of the State and with Cape Girardeau, Dent, Greene, Howell, Laclede, Oregon, Perry, Shannon, St. Louis, and Texas Counties being particularly vulnerable.

Figure 3.3.5.4 - Documented Sinkholes in Missouri (DNR 2013)



Although only seven events are described in this section as “notable events”, sinkholes are common to Missouri and the probability is high that they will occur in the future. To date, they have historically not had major impacts on development nor have they caused serious damage. (http://www.dnr.mo.gov/geology/geosrv/envgeo/sinkholes.htm) Thus, the severity of future events is likely to be low. Nevertheless, this could change with the increasing growth that is taking place in counties in susceptible regions of Missouri.

Impact of the Hazard

Sinkholes vary in size and location. These factors will determine the impact of the hazard, which could manifest as the loss of a personal vehicle, a building collapse, or damage to infrastructure such as roads, water, or sewer lines. Groundwater contamination is also a possible impact of a sinkhole. Because of the relationship of sinkholes to groundwater, pollutants captured in sinkholes (or dumped) can affect a community’s groundwater system. Sinkhole collapse could be triggered by large earthquakes, which

could be particularly problematic for the St. Louis metropolitan area. Sinkholes located in floodplains can absorb floodwaters but make detailed flood hazard studies difficult to model.

The information in the Table 3.3.5a is from the Impact Analysis of Potential for Detrimental Impacts of Hazards done for the Emergency Management Accreditation Program.

Table 3.3.5a EMAP Impact Analysis: Land Subsidence/Sinkholes

Subject	Detrimental Impacts
Health and Safety of Persons in the Area at Time of Incident	Localized impact expected to be moderate to severe for incident areas.
Health and Safety of Personnel Responding to the Incident	Limit impacts to personnel responding to the incident.
Continuity of Operations	Limited, unless facility is impacted.
Property, Facilities, and Infrastructure	Localized impact to facilities and infrastructure in the area of the incident. Some severe damage possible.
Delivery of Services	Localized disruption of roads and/or utilities may postpone delivery of some services.
The Environment	Localized impact expected to be moderate for incident area.
Economic and Financial Condition	Limited. Local economy and finances may be adversely affected, depending on damage.
Regulatory and Contractual Obligations	Regulatory waivers may be needed locally. Impact may temporarily reduce deliveries.
Reputation of or Confidence in the Entity	Localized impact expected to primarily adversely affect property owner(s) confidence in local entities development policies.

Synopsis

Most of Missouri's sinkholes are naturally occurring. Since it is possible to determine the geographical extent of this hazard in most cases, mitigation can be targeted. Avoiding the hazard is much more cost effective than altering or mitigating the sinkhole itself. Some counties, such as Greene and Christian, limit construction in areas near sinkholes. For additional information on vulnerability to land subsidence/sinkholes, see Section 3.5.5.

3.3.6 Severe Thunderstorms (includes damaging winds, hail, and lightning)

Description of Hazard

A thunderstorm is defined as a storm that contains lightning and thunder which is caused by unstable atmospheric conditions. When the upper air which is cold sinks and the warm moist air rises, storm clouds or 'thunderheads' develop resulting in thunderstorms. This can occur singularly, in clusters or in lines. Thunderstorms are classified into four major types, namely the supercell, squall line, multicell and single cell. Each of these varies depending on the relative conditions of the wind. The strongest type is called the supercell, which can be as wide as 24 kilometers or 15 miles. More often than not, it can bring severe weather conditions like extremely large hailstones and destructive tornadoes. It comes with straight-line winds of more than 130 km/h or 80 mph. As the strongest form of thunderstorm, it is associated with tornadoes and flashfloods. In severe cases, a thunderstorm is associated with hail or wind damage. A severe storm is characterized by winds as fast as 90 km/h or 56 mph. Furthermore, the diameter of hail is at least 25 millimeters or 1 inch. In addition to this, it is associated with the formation of tornadoes or funnel clouds. A severe thunderstorm may also come with a rainfall rate of more than 2.0 inches or 50 millimeters within an hour.

The National Weather Service defines a thunderstorm as severe if it produces a tornado, winds of at least 58 mph (50 knots), and/or hail at least one inch (1") in diameter. At any given moment across the world, there are about 1,800 thunderstorms occurring. Severe thunderstorms most often occur in Missouri in the spring and summer, during the afternoon and evenings, but can occur at any time. The entire State of Missouri is at risk to the damaging effects of Severe Thunderstorms. Other hazards associated with thunderstorms include: heavy rains causing flash flooding (discussed separately in Section 3.3.6), tornadoes (discussed separately in Section 3.3.7), damaging winds, hail, and lightning. This section of the risk assessment will focus on the damaging winds, hail, and lightning aspects of severe thunderstorms.

Damaging Winds

A severe thunderstorm can produce winds that can cause as much damage as a weak tornado and these winds can be life threatening. The damaging winds of thunderstorms include downbursts, microbursts, and straight-line winds. Downbursts are localized currents of air blasting down from a thunderstorm, which induce an outward burst of damaging wind on or near the ground. Microbursts are minimized downbursts covering an area of less than 2.5 miles across. They include a strong wind shear (a rapid change in the direction of wind over a short distance) near the surface. Microbursts may or may not include precipitation and can produce winds at speeds of more than 150 miles per hour. Damaging straight-line winds are high winds across a wide area that can reach speeds of 140 miles per hour.

Hail

Severe thunderstorms can produce hail that can be an inch or more in diameter and fall at speeds more than 100 mph. Hailstones of this size cause more than $1 billion in damages to properties and crops nationwide annually. Large hail can reach the size of grapefruit.

Lightning

Lightning—All thunderstorms produce lightning which often strikes outside of the area where it is raining and is known to fall more than 10 miles away from the rainfall area. Nationwide, lightning causes an average of 55 to 60 fatalities and 400 injuries each year. During the period of 2006 through 2012, eight people died in Missouri as a result of lightning strikes. Lightning events caused over $2.37 Million dollars in property damages in Missouri over the same six year period.

Historical Statistics

Damaging Winds

From January 1, 2003 to December 31, 2012, Missouri experienced 1,462 severe thunderstorms with damaging winds in excess of 67 miles per hour (50 knots). Table 3.3.6a provides annual statistics from 2003 to September 2012 for events 67 miles per hour or greater. During this ten-year period, there were 1,426 events with wind speed 58 knots or greater, eight deaths, 129 injuries, and over $150 Million reported property damages.

Table 3.3.6a Annual High Wind Events in Missouri with Wind Speed > 67 MPH

Year	# of Events 67 MPH or Greater	Deaths	Injuries	Property Damages	Crop Damages
2003	326	1	6	$797,000	$4,825,000
2004	134	2	50	$1,812,000	$7,000
2005	119	0	1	$1,249,000	$5,000
2006	158	2	42	$2,637,000	0
2007	72	0	2	$1,019,000	$760,000
2008	115	0	1	$4,114,000	0
2009	153	2	6	$143,294,000	0
2010	105	0	4	$1,278,600	$0
2011	190	0	11	$3,996,000	$105,000
2012	90	1	6	$1,390,000	$0
Totals	**1426**	**8**	**129**	**$161,586,600**	**$5,702,000**

Source: National Climatic Data Center (http://www.ncdc.noaa.gov/stormevents/choosedates.jsp?statefips=29%2CMISSOURI); *Through 12/31/2012

Some of the more notable damaging wind events are described in additional detail below:

June 2003: A line of strong storms moved across Clark County damaging 20,000 acres of crops (17,000 acres of corn and 3,000 acres of wheat).

August 2003: Two mobile homes were destroyed causing one injury and one fatality in Cass County. A camper trailer was overturned in Henry County causing three injuries.

July 2004: Severe winds caused damage at a campground near Truman Lake where 48 people were injured. One man that was driving his boat on the lake was killed. Other damages reported were to 35 homes and businesses.

July 2005: Intense straight line winds downed several trees in Laclede County and a few homes sustained structural damage. A roof was blown off of a large lumber yard and young boy was injured when a tree fell into his home.

March 2006: Four people were treated at a local hospital for minor injuries when their mobile home was destroyed near Portageville in New Madrid County.

April 2006: A man was killed when his mobile home was overturned in the Circle City area in Stoddard County. His son was also slightly injured. A NWS site survey indicated that straight line winds from 70 to 80 miles per hour were responsible for a path of widespread damage from Dexter east to Circle City.

July 19, 2006: Thunderstorm winds caused a partial collapse of a building that was due to be renovated in Lacledes Landing just north of the St. Louis Arch. Some of the bricks landed on the Eads Bridge causing the bridge to be temporarily closed to traffic. On the Arch grounds 120 trees were blown over and 90 others were severely damaged. At Busch Stadium, the infield tarp (seen in Figure 3.3.6.1) was torn and 30 people sustained injuries due to flying debris, including trash cans and vendor stands that were blown over within the stadium. Also, numerous trees, tree limbs, street signs and power lines were blown down throughout the City. By the time the storms moved south of the St. Louis area, an estimated 500,000 customers were without electric power.

Figure 3.3.6.1 - Infield Tarp at Busch Stadium in St. Louis

Photo provided by SEMA

August 2009: A downburst on August 7th caused extensive damage to several businesses in a strip mall on the west side of Jefferson City; damages were estimated at $1,000,000. On August 12, downburst winds did considerable damage to a 25 block area in the southwest section of Joplin. Power lines were downed with widespread power outages and nearly 60 windows were broken at the St. Johns Regional Medical Center. Damages from this event were estimated at $500,000.

August 2010: Isolated storms developed along an outflow boundary that was moving South through St. Charles County. Thunderstorm winds were in excess of 61 knots. These winds knocked down numerous trees, tree limbs and power lines. The width of the damage path was about a half a mile to a mile wide.

August 2011: An isolated supercell drifted towards Maryville and produced winds in excess of 80 MPH. The storm resulted in $1 Million in property damages and $100 thousand in crop damages. This storm resulted in the evacuation of the Missouri State Fairgrounds, and knocked down the Missouri State Patrol's primary radio tower in St. Joseph. Luckily, there were no deaths or injuries associated with this storm.

April 2012: A supercell thunderstorm arrived between 3:40 and 3:50 PM causing localized damage near Busch Stadium. Winds up to 60 MPH collapsed a tent at a sports bar near the stadium, resulting in 100 injuries and one death.

Hail

From January 1, 2003 to December 31, 2012, Missouri experience 7,929 hailstorms with hail size an inch in diameter or larger. Table 3.3.6b provides annual statistics from January 2003 to September 2012 for hail three-fourths of an inch or larger.

Table 3.3.6b Annual Hail Events in Missouri with Hail 0.75 Inches in Diameter or Larger

Year	# of Events .75 in. or larger	Deaths	Injuries	Property Damages	Crop Damages
2003	1279	0	0	$18551,000	$71,000
2004	679	0	0	$8,844,000	$1,026,000
2005	670	0	0	$85,000	$5,000
2006	1270	0	1	$10,088,000	0
2007	499	0	0	$120,000	0
2008	831	0	3	$1,957,000	0
2009*	479	0	1	$645,000	$0
2010	558	0	0	$1,272,000	$0
2011	1141	0	0	$9,350,000	$10,000
2012	523	0	1	$250,000	$0
Total	**7929**	**0**	**6**	**$51,162,000**	**$1,112,000**

Source: National Climatic Data Center (http://www.ncdc.noaa.gov/stormevents/choosedates.jsp?statefips=29%2CMISSOURI); *Through 12/31/2012

Lightning

From January 1, 2003 to December 31, 2012, 132 damaging lightning events were reported in Missouri. There are likely thousands of lightning events that occur annually that go unreported either because damages did not occur or because the damages were not reported to be captured in NCDC statistics. Table 3.3.6c provides annual statistics from 2003 to 2012 reported lightning events in Missouri:

Table 3.3.6c Annual Reported Damaging Lightning Events in Missouri

Year	# of Lightning Events	Deaths	Injuries	Property Damages	Crop Damages
2003	15	0	0	$17,000	0
2004	11	0	0	$120,000	0
2005	18	2	5	$810,000	0
2006	12	0	2	$87,000	$2,000
2007	8	2	5	$227,000	0
2008	18	0	17	$704,000	0
2009*	11	2	1	$164,000	0
2010	18	1	7	$670,200	$0
2011	18	3	6	$509,000	$0
2012	3	0	4	$1,000	$14,000
Total	**132**	**10**	**47**	**$3,309,200**	**$16,000**

Source: National Climatic Data Center (http://www.ncdc.noaa.gov/stormevents/choosedates.jsp?statefips=29%2CMISSOURI); *Through 12/31/2012

Table 3.3.6d provides details on the Presidential declarations in Missouri that included high winds or severe storms from 1975 to the present.

Table 3.3.6d Presidential Declarations in Missouri Including High Winds or Severe Storms, 1975 to Present

Date	Disaster No.	Incident Type	Counties Declared	Type of Assistance
May 3, 1975	DR-466	Tornadoes, High Winds, Hail	Caldwell, Newton, Macon, Shelby	PA & IA
July 21, 1976	DR-516	Severe Storms, Flooding	N/A	PA & IA
September 14, 1977	DR-538	Severe Storms, Flooding	N/A	PA & IA
May 15, 1980	DR-620	Severe Storms, Tornadoes	Pettis	IA Only
August 26, 1982	DR-667	Severe Storms, Flooding	N/A	PA & IA
December 10, 1982	DR-672	Severe Storms, Flooding	N/A	PA & IA
June 21, 1984	DR-713	Severe Storms, Flooding	N/A	PA & IA
October 14, 1986	DR-779	Severe Storms, Flooding	N/A	PA & IA
May 24, 1990	DR-867	Flooding, Severe Storm	N/A	PA & IA
May 11, 1993	DR-989	Severe Storm, Flooding	Jefferson, Lincoln, Marion, Pike, Ralls, St. Charles, St. Louis, Ste. Genevieve	IA Only

Date	Disaster No.	Incident Type	Counties Declared	Type of Assistance
July 9, 1993	DR-995	Flooding, Severe Storm	Adair, Andrew, Atchison, Audrain, Barry, Barton, Bates, Benton, Boone, Buchanan, Caldwell, Callaway, Camden, Cape Girardeau, Carroll, Cass, Chariton, Christian, Clark, Clay, Clinton, Cole, Cooper, Crawford, Dade, Dallas, Daviess, DeKalb, Douglas, Franklin, Gasconade, Gentry, Greene, Grundy, Harrison, Henry, Hickory, Holt, Howard, Howell, Jackson, Jasper, Jefferson, Johnson, Knox, Laclede, Lafayette, Lawrence, Lewis, Lincoln, Linn, Livingston, Macon, Maries, Marion, McDonald, Mercer, Miller, Mississippi, Moniteau, Monroe, Montgomery, Morgan, New Madrid, Newton, Nodaway, Osage, Ozark, Pemiscot, Perry, Pettis, Phelps, Pike, Platte, Polk, Pulaski, Putnam, Ralls, Randolph, Ray, Saline, Schuyler, Scotland, Scott, Shelby, St. Charles, St. Clair, St. Francois, St. Louis, Ste. Genevieve, Stoddard, Stone, Sullivan, Taney, Texas, Vernon, Warren, Washington, Wayne, Webster, Worth, Wright, St. Louis City*	IA
			Adair, Andrew, Atchison, Barry, Barton, Bates, Benton, Boone, Buchanan, Caldwell, Callaway, Camden, Cape Girardeau, Carroll, Cass, Chariton, Christian, Clark, Clay, Clinton, Cole, Cooper, Crawford, Dade, Dallas, Daviess, DeKalb, Douglas, Franklin, Gasconade, Gentry, Greene, Grundy, Harrison, Henry, Holt, Howard, Jackson, Jefferson, Johnson, Knox, Laclede, Lafayette, Lawrence, Lewis, Lincoln, Linn, Livingston, Macon, Maries, Marion, McDonald, Mercer, Miller, Mississippi, Moniteau, Monroe, Montgomery, Morgan, New Madrid, Newton, Nodaway, Osage, Ozark, Pemiscot, Perry, Pettis, Pike, Platte, Polk, Pulaski, Putnam, Ralls, Ray, Saline, Schuyler, Scotland, Shelby, St. Charles, St. Clair, St. Louis, Ste. Genevieve, Stone, Sullivan, Texas, Warren, Worth, Wright, St. Louis City	PA
December 1, 1993	DR-1006	Flooding, Severe Storm, Tornadoes	Bollinger, Butler, Cape Girardeau, Carter, Crawford, Dent, Franklin, Howell, Iron, Jefferson, Madison, Oregon, Perry, Pulaski, Reynolds, Ripley, Shannon, St. Francois, St. Louis, Ste. Genevieve, Stoddard, Texas, Washington, Wayne	IA
			Carter, Dent, Howell, Iron, Madison, Oregon, Perry, Reynolds, Shannon, St. Francois, Ste. Genevieve, Texas, Washington, Wayne	PA
April 21, 1994	DR-1023	Severe Storm, Flooding, Tornadoes	Barry, Callaway, Clay, Cole, Franklin, Jefferson, Lincoln, Morgan, Pemiscot, Phelps, Pulaski, Reynolds, Shannon, St. Charles, St. Louis, Vernon, Washington, St. Louis City*	IA Only

Date	Disaster No.	Incident Type	Counties Declared	Type of Assistance
June 2, 1995	DR-1054	Severe Storm, Tornadoes, Hail, Flooding	Adair, Andrew, Atchison, Barry, Barton, Bates, Benton, Boone, Callaway, Camden, Cape Girardeau, Carroll, Cass, Chariton, Clark, Cole, Cooper, Dallas, Daviess, DeKalb, Franklin, Gasconade, Gentry, Henry, Howard, Jackson, Jasper, Jefferson, Johnson, Lafayette, Lewis, Lincoln, Linn, Macon, Maries, McDonald, Mercer, Miller, Mississippi, Moniteau, Montgomery, Morgan, New Madrid, Newton, Nodaway, Osage, Pemiscot, Perry, Ray, Saline, Scotland, Scott, St. Charles, St. Clair, St. Francois, St. Louis, Ste. Genevieve, Stone, Sullivan, Vernon, Warren, St. Louis City*	IA
			Andrew, Atchison, Barry, Bates, Benton, Boone, Callaway, Cape Girardeau, Carroll, Chariton, Clark, Cole, Cooper, Daviess, DeKalb, Franklin, Gasconade, Gentry, Henry, Howard, Jefferson, Johnson, Lafayette, Linn, Macon, McDonald, Mercer, Miller, Mississippi, Moniteau, Montgomery, Nodaway, Perry, Ray, Saline, St. Charles, St. Clair, St. Louis, Ste. Genevieve, Stone, Sullivan, Vernon, Warren	PA
October 14, 1998	DR-1253	Severe Storm and Flooding	Carroll, Clay, Jackson, Platte, Ray	IA
			Andrew, Barton, Caldwell, Carroll, Cedar, Chariton, Clay, Dade, DeKalb, Jackson, Linn, Livingston, Macon, Miller, Moniteau, Morgan, Platte, Polk, Ray	PA
October 19, 1998**	DR-1256	Severe Storm and Flooding	Jackson, St. Louis, St. Louis City*	IA Only
April 20, 1999	DR-1270	Severe Storms and Flooding	Andrew, Cole, Iron, Macon, Madison, Osage	IA Only
May 12, 2000	DR-1328	Severe Thunderstorms and Flash Flooding	Crawford, Franklin, Jefferson, Gasconade, St. Charles, St. Francois, St. Louis, Ste. Genevieve, Warren, Washington	IA
			Franklin, Gasconade, Jefferson	PA
May 6, 2002	DR-1412	Severe Storms and Tornadoes	N/A ?	PA & IA
May 6, 2003	DR-1463	Tornadoes, Severe Storms, Flooding	Barry, Barton, Bates, Benton, Bollinger, Buchanan, Camden, Cape, Cass, Cedar, Christian, Clay, Clinton, Cooper, Crawford, Dade, Dallas, Dent, Douglas, Franklin, Knox, Gasconade, Girardeau, Greene, Henry, Hickory, Iron, Jackson, Jasper, Jefferson, Johnson, Laclede, Lafayette, Lawrence, McDonald, Miller, Monroe, Morgan, Newton, Osage, Perry Pettis, Phelps, Platte, Polk, Pulaski, Ray, St. Francois, St. Louis, Sainte Genevieve, Saline, Scott, St. Clair, Stoddard, Stone, Taney, Vernon, Washington, Webster	IA & PA
			Bollinger, Crawford, Franklin, Gasconade, Knox, Maries, Miller, Oregon, Osage, Pulaski, Washington	PA

Date	Disaster No.	Incident Type	Counties Declared	Type of Assistance
June 11, 2004	DR-1524	Tornadoes, Severe Storms, Flooding	Adair, Andrew, Bates, Benton, Caldwell, Carroll, Cass, Cedar, Chariton, Clay, Clinton, Daviess, DeKalb, Gentry, Grundy, Harrison, Henry, Hickory, Jackson, Johnson, Knox, Linn, Livingston, Macon, Mercer, Monroe, Nodaway, Platte, Polk, Randolph, Ray, Shelby, St. Clair, Sullivan, Vernon, and Worth	IA Only
March 16, 2006	DR-1631	Tornadoes, Severe Storms	Bates, Benton, Boone, Carroll, Cass, Cedar, Christian, Cooper, Crawford, Greene, Henry, Hickory, Howard, Iron, Jefferson, Johnson, Lawrence, Lincoln, Mississippi, Monroe, Montgomery, Morgan, New Madrid, Newton, Perry, Pettis, Phelps, Putnam, Randolph, St. Clair, Ste. Genevieve, Scott, Saline, Taney, Vernon, Webster, Wright	IA
			Bates, Bollinger, Benton, Boone, Carroll, Cedar, Christian, Davies, Greene, Henry, Hickory, Howard, Iron, Lawrence, Monroe, Montgomery, Morgan, Perry, Pettis, Putnam, Randolph, Ray, Saline, St. Clair, Vernon, Washington, Webster, Wright	PA
April 5, 2006	DR-1635	Tornadoes, Severe Storms	Andrew, Butler, Dunklin, Pemiscot, St. Francois, Stoddard	IA
			Jefferson, Andrew, Pettis, Pemiscot, St. Francis	PA
November 2, 2006	DR-1667	Severe Storms	St. Louis City*	PA Only
July 21, 2006	EM-3267	Tornadoes, Severe Storms	St. Louis County, St. Louis City*, Dent, Iron, Jefferson, St. Charles, Washington	PA
June 11, 2007	DR-1708	Severe Storms/Flooding	Atchison, Nodaway, Holt, Worth, Gentry, Harrison, Mercer, Gundy, Sullivan, Linn, Livingston, Daviess, DeKalb, Andrew, Buchanan, Clinton, Caldwell, Carroll, Chariton, Howard, Saline, Ray, Lafayette, Platte, Clay, Jackson, Cass, Bates, Morgan, Osage	IA & PA
September 21, 2007	DR-1728	Severe Storms/Flooding	Dade, Lawrence, Polk, Greene, Dallas, Webster, Laclede	PA
February 5, 2008	DR-1742	Severe Storms Tornadoes, and Flooding	Newton, McDonald, Barry, stone, Webster, Dallas, Laclede, Phelps, Maries	PA
March 19, 2008	DR-1749	Severe Storms and Flooding	Bollinger, Carter, Christian, Franklin, Greene, Iron, Jasper, Jefferson, Maries, Newton, Oregon, Phelps, Pulaski, Reynolds, St. Francois, Stone, Texas, Washington, and Wayne Counties	IA

Date	Disaster No.	Incident Type	Counties Declared	Type of Assistance
			Audrain, Barry, Barton, Boone, Bollinger, Butler, Callaway, Camden, Cape Girardeau, Carter, Cedar, Christian, Cole, Cooper, Crawford, Dade, Dallas, Dent, Douglas, Dunklin, Franklin, Gasconade, Greene, Hickory, Howard, Howell, Iron, Jasper, Jefferson, Laclede, Lawrence, Lincoln, Madison, Maries, McDonald, Miller, Mississippi, Montgomery, Moniteau, Morgan, New Madrid, Newton, Oregon, Osage, Ozark, Pemiscot, Perry, Phelps, Pike, Polk, Pulaski, Reynolds, Ripley, St. Charles, St. Clair, St. Francois, St. Louis, Ste. Genevieve, Shannon, Scott, Stoddard, Stone, Taney, Texas, Vernon, Warren, Washington, Wayne, Webster, and Wright	PA
May 23, 2008	DR-1760	Severe Storms and Tornadoes	Jasper, Newton and Barry	IA
June 25, 2008	DR-1773	Severe Storms and Flooding	Adair, Andrew, Callaway, Cass, Chariton, Clark, Gentry, Greene, Harrison, Holt, Johnson, Lewis, Lincoln, Linn, Livingston, Macon, Marion, Monroe, Nodaway, Pike, Putnam, Ralls, St. Charles, Stone, Taney, Vernon, and Webster	IA
			Adair, Andrew, Atchison, Audrain, Bates, Callaway, Cape Girardeau, Carroll, Chariton, Clark, Christian, Daviess, Gentry, Grundy, Harrison, Howard, Holt, Knox, Lewis, Lincoln, Linn, Macon, Marion, Miller, Mississippi, Monroe, Morgan, Nodaway, Perry, Pettis, Pike, Putnam, Ralls, Ray, Shelby, St. Charles, Stone, Sullivan, Taney, and Vernon Counties for Public Assistance. Andrew, Atchison, Buchanan, Cape Girardeau, Clark, Holt, Jefferson, Lewis, Lincoln, Livingston, Marion, Mercer, Mississippi, New Madrid, Nodaway, Pemiscot, Perry, Pike, Platte, Polk, Ralls, Randolph, Saline, Schuyler, Scotland, St. Charles, St. Louis, Ste. Genevieve, Scott, the Independent City of St. Louis, Webster, and Worth	PA?
November 13, 2008	DR-1809	Severe Storms, Flooding and Tornadoes	Boone, Callaway, Chariton, Howell, Jefferson, Lewis, Lincoln, Linn, Marion, Montgomery, Osage, Schuyler, St. Charles, St. Louis, Stone, Taney, Texas, and Webster Counties and the Independent City of St. Louis	IA
			Adair, Audrain, Barry, Bollinger, Butler, Callaway, Cape Girardeau, Carter, Chariton, Christian, Clark, Crawford, Dent, Douglas, Dunklin, Howard, Howell, Knox, Lewis, Lincoln, Linn, Madison, Maries, Marion, Miller, Mississippi, New Madrid, Oregon, Ozark, Perry, Ralls, Randolph, Ray, Reynolds, Ripley, Schuyler, Scotland, Scott, Shannon, Shelby, St. Genevieve, Stoddard, Stone, Sullivan, Taney, Texas, Wayne, Webster, and Wright	PA
June 19, 2009	DR-1847	Severe Storms, Tornadoes, and Flooding	Adair, Barry, Barton, Bollinger, Cape Girardeau, Christian, Dade, Dallas, Dent, Douglas, Greene, Howell, Iron, Jasper, Jefferson, Laclede, Lawrence, Madison, Newton, Ozark, Polk, Reynolds, Ripley, St. Francois, Shannon, Texas, Washington, Webster	IA

Date	Disaster No.	Incident Type	Counties Declared	Type of Assistance
			Adair, Barton, Bollinger, Camden, Cape Girardeau, Cedar, Crawford, Dade, Dallas, Dent, Douglas, Greene, Hickory, Howell, Iron, Jasper, Knox, Laclede, Lewis, Madison, Maries, Marion, Miller, Newton, Oregon, Ozark, Perry, Phelps, Polk, Pulaski, Ray, Reynolds, Ripley, St. Francois, Ste. Genevieve, Saline, Shannon, Shelby, Stone, Sullivan, Texas, Vernon, Washington, Wayne, Webster, Wright	PA
August 17, 2010	DR-1934	Severe Storms, Flooding, and Tornadoes	Adair, Andrew, Atchison, Buchanan, Caldwell, Carroll, Cass, Charlton, Clark, Clinton, Daviess, DeKalb, Gentry, Grundy, Harrison, Holt, Howard, Jackson, Knox, Lafayette, Lewis, Linn, Livingston, Marion, Mercer, Monroe, Nodaway, Perry, Pike, Putnam, Ralls, Ray, Schuyler, Scotland, Shelby, Sullivan, Worth	PA
May 9, 2011	DR-1980	Severe Storms, Tornadoes, and Flooding	Bollinger, Butler, Cape Girardeau, Carter, Dunkin, Howell, Jasper, Lawrence, McDonald, Mississippi, New Madrid, Newton, Pemiscot, Pettis, Phelps, Pulaski, Raynolds, Ripley, Saint Francois, Saint Louis, Scott, Stoddard, Stone, Taney, Wayne	IA
			Barry, Bollinger, Butler, Cape Girardeau, Carter, Christian, Douglas, Dunkin, Howell, Iron, Jasper, Madison, McDonald, Miller, Mississippi, New Madrid, Newton, Oregon, Ozark, Pemiscot, Perry, Pettis, Polk, Reynolds, Ripley, Saint Francois, Saint Louis, Sainte Genevieve, Scott, Shannon, Stoddard, Stone, Taney, Texas, Washington, Wayne, Webster, Wright	PA

Source: Federal Emergency Management Agency, State Emergency Management Agency
Note:*IA denotes Individual Assistance; PA denotes Public Assistance

According to the USDA Risk Management Agency, insured crop losses throughout the State of Missouri as a result of hail conditions for the four year period of 2009 - 2012 totaled $18,461,799. During this same period, insured crop losses for wind/excess wind were $4,757,064. A detailed listing of insured crop losses by crop, county, and, year for insured crop losses is provided at the following link: USDA Risk Management Agency Crop Claims Data.

Measure of Probability and Severity
Probability: High
Severity: High
Severe thunderstorm events are a common occurrence throughout Missouri. Considering just damaging wind events with wind speeds at or above 58 knots, there were fewer than 150 events per year on the average. Therefore, the probability has been determined to be high. Severe thunderstorm events can cause deaths either by flying debris, heavy objects being blown over, or lightning. In addition this hazard often causes disruption in power supply. Repairs can be costly and indirect damages such as interruption of public services and business occur.

Impact of the Hazard

According to NCDC, During the 10-year period from 2003-2012, high wind (over 67 mph), hail, and lightning caused an annual average of 1.8 deaths, 18 injuries, $21 million in property damages and nearly $683,000 in crop damages. The property and crop damage figures reported in NCDC are early

estimates and are likely very low. For the period from 1993 to 2013 crop damages are roughly $63,232,281 and property damage was $270,339,732 as a result of wind and hail. According to this data, severe thunderstorms have a significant impact both in terms of human safety as well as economic losses.

Table 3.3.6e EMAP Impact Analysis: Severe Thunderstorms

Subject	Detrimental Impacts
Health and Safety of Persons in the Area at Time of Incident	Localized impact expected to be severe for incident areas and moderate to light for other adversely affected areas.
Health and Safety of Personnel Responding to the Incident	Localized impact expected to limit damage to personnel in the areas at the time of the incident.
Continuity of Operations	Damage to facilities/personnel in the area of the incident may require temporary relocation of some operations.
Property, Facilities, and Infrastructure	Localized impact to facilities and infrastructure in the area of the incident. Some severe damage possible.
Delivery of Services	Localized disruption of roads, facilities, and/or utilities caused by incident may postpone delivery of some services.
The Environment	Localized impact expected to be severe for incident areas and moderate to light for other areas affected by the storm or HazMat spills.
Economic and Financial Condition	Losses to private structures covered, for the most part, by private insurance.
Regulatory and Contractual Obligations	Regulatory waivers may be needed locally. Fulfillment of some contracts may be difficult. Impact may temporarily reduce deliveries.
Reputation of or Confidence in the Entity	Ability to respond and recover may be questioned and challenged if planning, response, and recovery not timely and effective.

Synopsis

Severe thunderstorms losses are usually attributed to associated hazards of hail, downburst winds, lightning and heavy rains. Losses to hail and high wind are typically insured losses that are localized and do not result in presidential disaster declarations. However, in some cases, impacts are severe and widespread and assistance outside the State capabilities is necessary. Hail and wind also can have devastating impacts on crops. Severe thunderstorms/heavy rains that lead to flooding are accounted for in the riverine flooding profile.

Additional information on severe thunderstorm vulnerability is located in Section 3.5.6.

3.3.7 Tornadoes

Description of Hazard

Tornadoes are cyclical windstorms often associated with the Midwestern areas of the United States. Weather conditions conducive to tornadoes often produce a wide range of other dangerous storm activities, including severe thunderstorms, downbursts, straight-line winds, lightning, hail, and heavy rains. For the purpose of this analysis, tornadoes are considered in one category. Other severe weather activities associated with tornadoes are profiled separately in this document in Section 3.3.6 Severe Thunderstorms. Figure 3.3.7.1 on the following page illustrates damage from a tornado that struck Gladstone, MO on May 1, 2008.

Figure 3.3.7.1 - Damage in Gladstone, MO from May 1, 2008 Tornado

Photo Courtesy of SEMA

Essentially, tornadoes are a vortex storm with two components of winds. The first is the rotational winds that can measure up to 500 miles per hour, and the second is an uplifting current of great strength. The dynamic strength of both these currents can cause vacuums that can overpressure structures from the inside.

Although tornadoes have been documented in all 50 states, the majority of strong events occur in the central United States. The unique geography of the central United States allows for the development of thunderstorms that spawn tornadoes. The jet stream, which is a high-velocity stream of air, determines which area of the central United States will be prone to tornado development. The jet stream normally separates the cold air of the north from the warm air of the south. During the winter, the jet stream

flows west to east from Texas to the Carolina coast. As the sun "moves" north, so does the jet stream, which at summer solstice flows from Canada across Lake Superior to Maine. During its move northward in the spring and its recession south during the fall, the jet stream crosses Missouri, causing the large thunderstorms that breed tornadoes.

Tornadoes spawn from the largest thunderstorms. The associated cumulonimbus clouds can reach heights of up to 55,000 feet above ground level and are commonly formed when Gulf air is warmed by solar heating. The moist, warm air is overridden by the dry cool air provided by the jet stream. This cold air presses down on the warm air, preventing it from rising, but only temporarily. Soon, the warm air forces its way through the cool air and the cool air moves downward past the rising warm air. This air movement, along with the deflection of the earth's surface, can cause the air masses to start rotating. This rotational movement around the location of the breakthrough forms a vortex, or funnel. If the newly created funnel stays in the sky, it is referred to as a funnel cloud. However, if it touches the ground, the funnel officially becomes a tornado.

A typical tornado can be described as a funnel-shaped cloud that is "anchored" to a cloud, usually a cumulonimbus that is also in contact with the earth's surface. This contact on average lasts 30 minutes and covers an average distance of 15 miles. The width of the tornado (and its path of destruction) is usually about 300 yards. However, tornadoes can stay on the ground for upward of 300 miles and can be up to a mile wide. The National Weather Service, in reviewing tornadoes occurring in Missouri between 1950 and 1996, calculated the mean path length at 2.27 miles and the mean path area at 0.14 square mile.

The average forward speed of a tornado is 30 miles per hour but may vary from nearly stationary to 70 miles per hour. The average tornado moves from southwest to northeast, but tornadoes have been known to move in any direction. Tornadoes are most likely to occur in the afternoon and evening, but have been known to occur at all hours of the day and night.

Tornadoes are classified according to the EF- Scale (the original F – Scale was developed by Dr. Theodore Fujita, a renowned severe storm researcher). The Enhanced F- Scale, below, attempts to rank tornadoes according to wind speed based on the damage caused. This update to the original F scale was implemented in the U.S. on February 1, 2007. Table 3.3.7c lists the number of Missouri Tornadoes by F-Scale, 1950–2012.

Table 3.3.7a Enhanced F Scale for Tornado Damage

FUJITA SCALE			DERIVED EF SCALE		OPERATIONAL EF SCALE	
F Number	Fastest 1/4-mile (mph)	3 Second Gust (mph)	EF Number	3 Second Gust (mph)	EF Number	3 Second Gust (mph)
0	40-72	45-78	0	65-85	0	65-85
1	73-112	79-117	1	86-109	1	86-110
2	113-157	118-161	2	110-137	2	111-135
3	158-207	162-209	3	138-167	3	136-165
4	208-260	210-261	4	168-199	4	166-200
5	261-318	262-317	5	200-234	5	Over 200

Source: The National Weather Service, www.spc.noaa.gov/faq/tornado/ef-scale.html

The Enhanced F-scale still is a set of wind estimates (not measurements) based on damage. It uses three-second gusts estimated at the point of damage based on a judgment of 8 levels of damage to the 28 indicators. These estimates vary with height and exposure. **Important**: The 3 second gust is not the same wind as in standard surface observations. Standard measurements are taken by weather stations in open exposures, using a directly measured, "one minute mile" speed.

Table 3.3.7b Enhanced F Scale Damage Indicators

NUMBER	DAMAGE INDICATOR	ABBREVIATION
1	Small barns, farm outbuildings	SBO
2	One- or two-family residences	FR12
3	Single-wide mobile home (MHSW)	MHSW
4	Double-wide mobile home	MHDW
5	Apt, condo, townhouse (3 stories or less)	ACT
6	Motel	M
7	Masonry apt. or motel	MAM
8	Small retail bldg. (fast food)	SRB
9	Small professional (doctor office, branch bank)	SPB
10	Strip mall	SM
11	Large shopping mall	LSM
12	Large, isolated ("big box") retail bldg.	LIRB
13	Automobile showroom	ASR
14	Automotive service building	ASB
15	School - 1-story elementary (interior or exterior halls)	ES
16	School - jr. or sr. high school	JHSH
17	Low-rise (1-4 story) bldg.	LRB
18	Mid-rise (5-20 story) bldg.	MRB
19	High-rise (over 20 stories)	HRB
20	Institutional bldg. (hospital, govt. or university)	IB
21	Metal building system	MBS
22	Service station canopy	SSC
23	Warehouse (tilt-up walls or heavy timber)	WHB
24	Transmission line tower	TLT
25	Free-standing tower	FST
26	Free standing pole (light, flag, luminary)	FSP
27	Tree - hardwood	TH
28	Tree - softwood	TS

Source: www.spc.noaa.gov/faq/tornado/ef-scale.html

Table 3.3.7c Missouri Tornadoes by F-Scale, 1950–2012

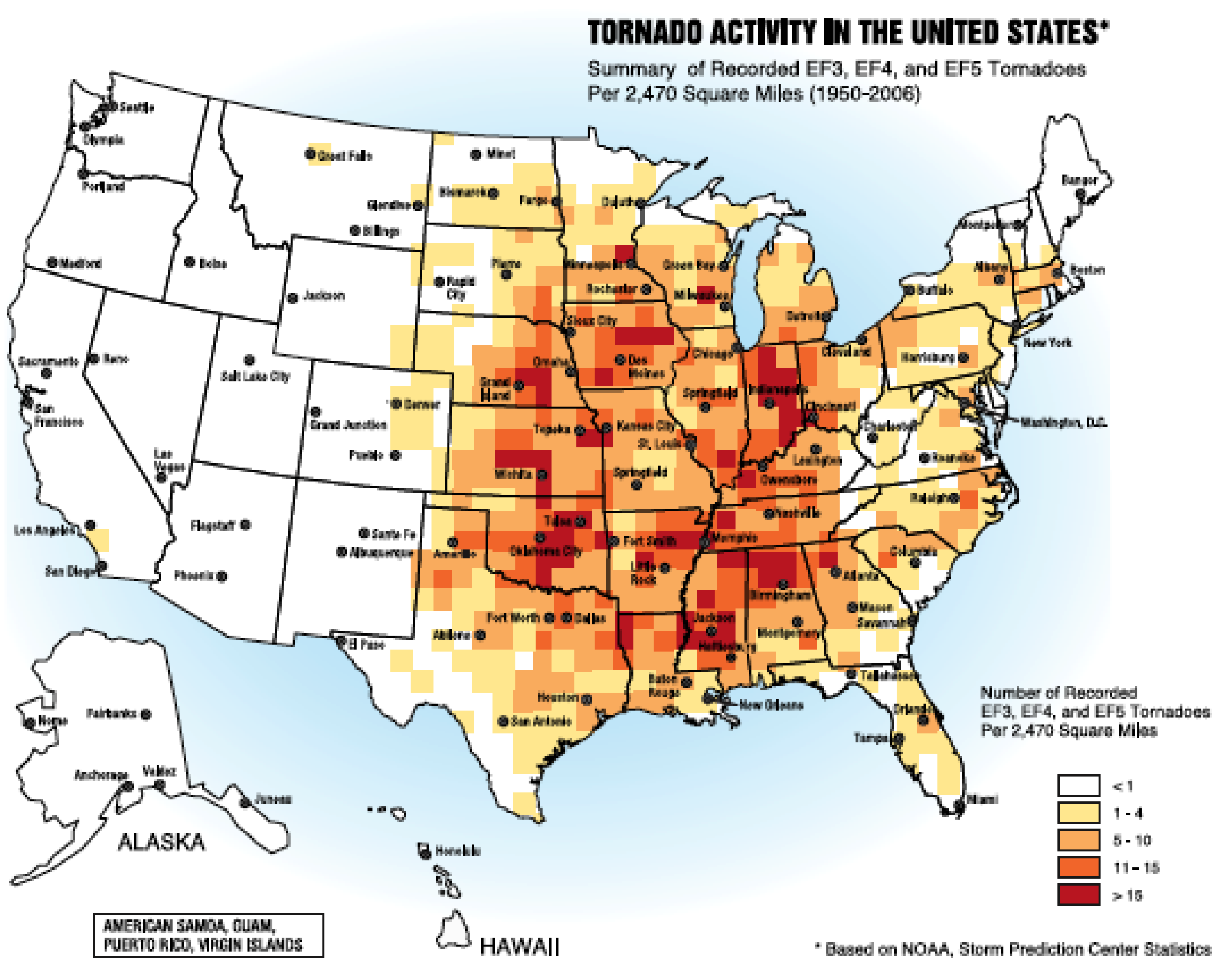
Scale	Percentage
F0	34
F1	38
F2	19

F3	7
F4	3
F5	<1*

*Note: During this time frame, there were 2 F-5 tornadoes in 1957 in Jackson County and 2011 in Jasper County. This translates to less than 1% overall.

Figure 3.3.7.2 illustrates the number of EF3, EF4, and EF5 tornadoes recorded in the United States per 2,470 square miles between 1950 and 2006. Missouri is in a region of the U.S. that has recorded 1 to above 15 EF3, EF4, and EF5 Tornadoes.

Figure 3.3.7.2 Tornado Activity in the United States

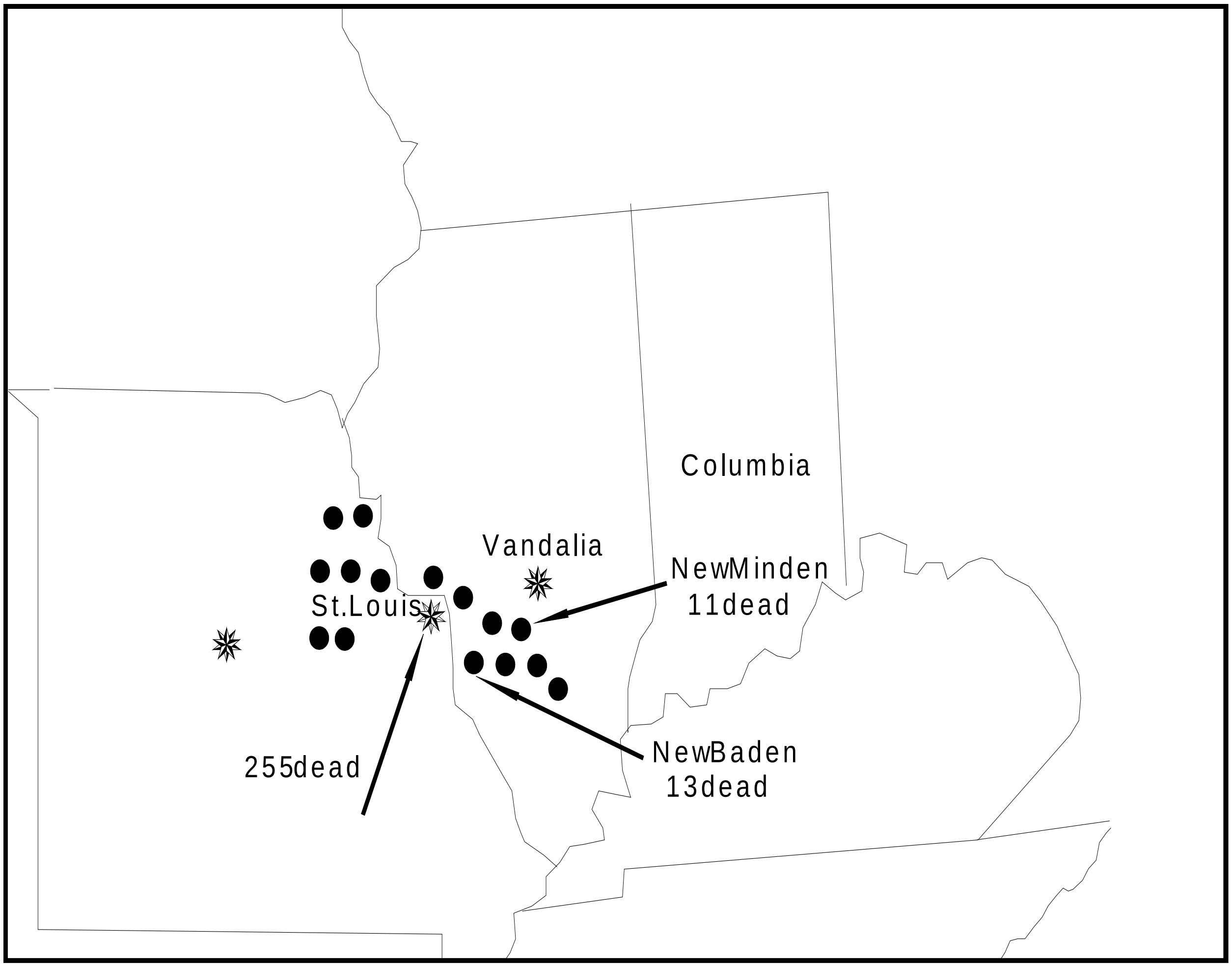


Historical Statistics

Historically, Missouri has experienced numerous tornadoes of varied intensities. The first major tornado event on record occurred on May 27, 1896, between the hours of 2 and 8 p.m., a series of 18 tornadoes

known as the "St. Louis, Missouri, Outbreak" struck Missouri and Illinois. These tornadoes resulted in 306 deaths and $15 million in damage (see Figure 3.3.7.3). It is important to note that these damage estimates have not been adjusted for inflation.

Figure 3.3.7.3 - St. Louis, Missouri, Tornado Outbreak of 1896

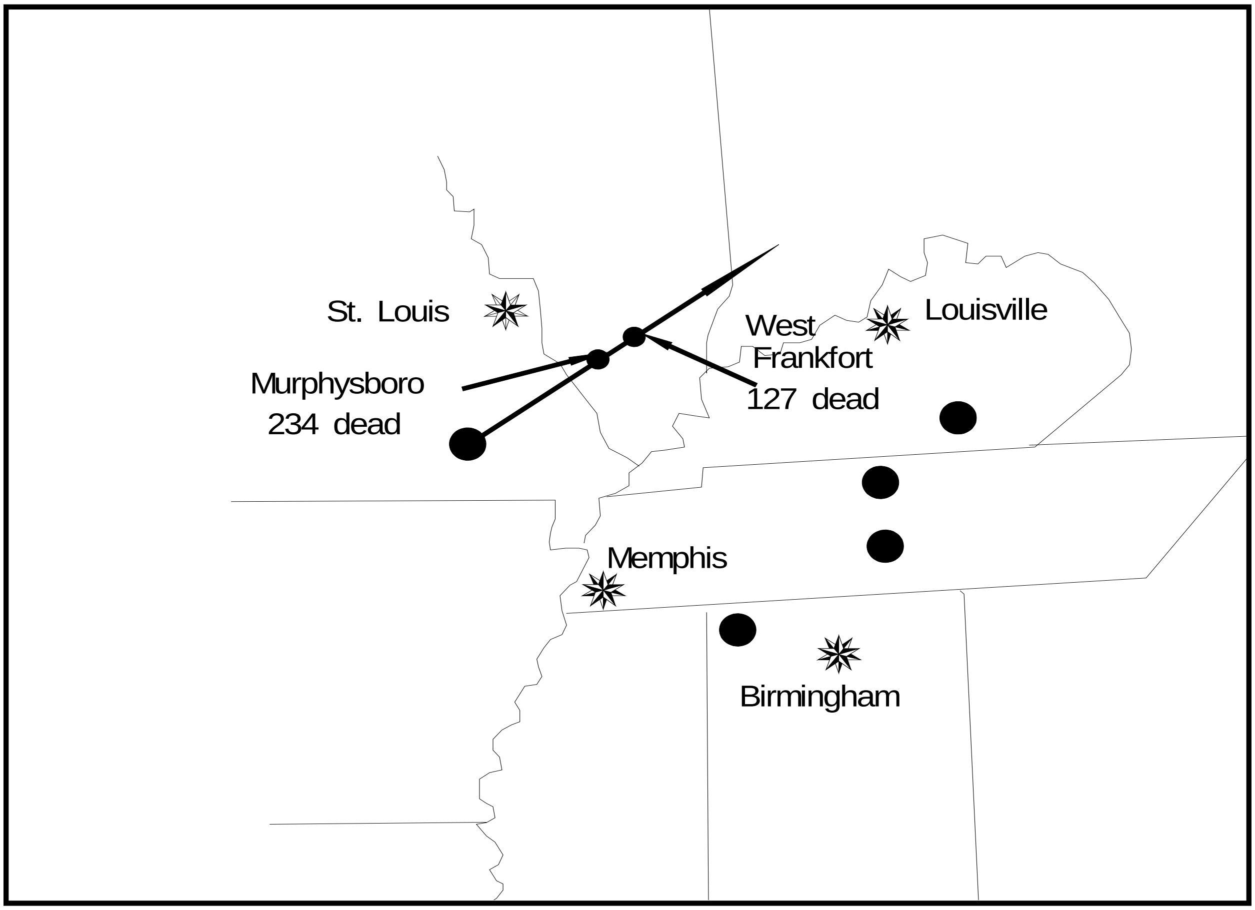


Source: State Hazard Analysis, October 2009

The National Climatic Data Center reports that 2312 tornadoes occurred in Missouri from 1950 to June 4, 2012, with 389 deaths and over $5.2 billion in damage. This averages 35 tornadoes per year, roughly $84 M a year in damages and 6 deaths per year.

The worst tornado in U.S. history, in terms of deaths and destruction, occurred in Missouri on March 18, 1925, between 1 and 6 p.m. (see Figure 3.3.7.4). The great "tri-state" tornado originated in Reynolds County and it proceeded east-northeast through the southern quarter of Illinois and into Indiana, covering 219 miles. It caused over $18 million in damage, affected six states, and killed 689 people.

Figure 3.3.7.4 - The Great Tri-State Tornado of 1925



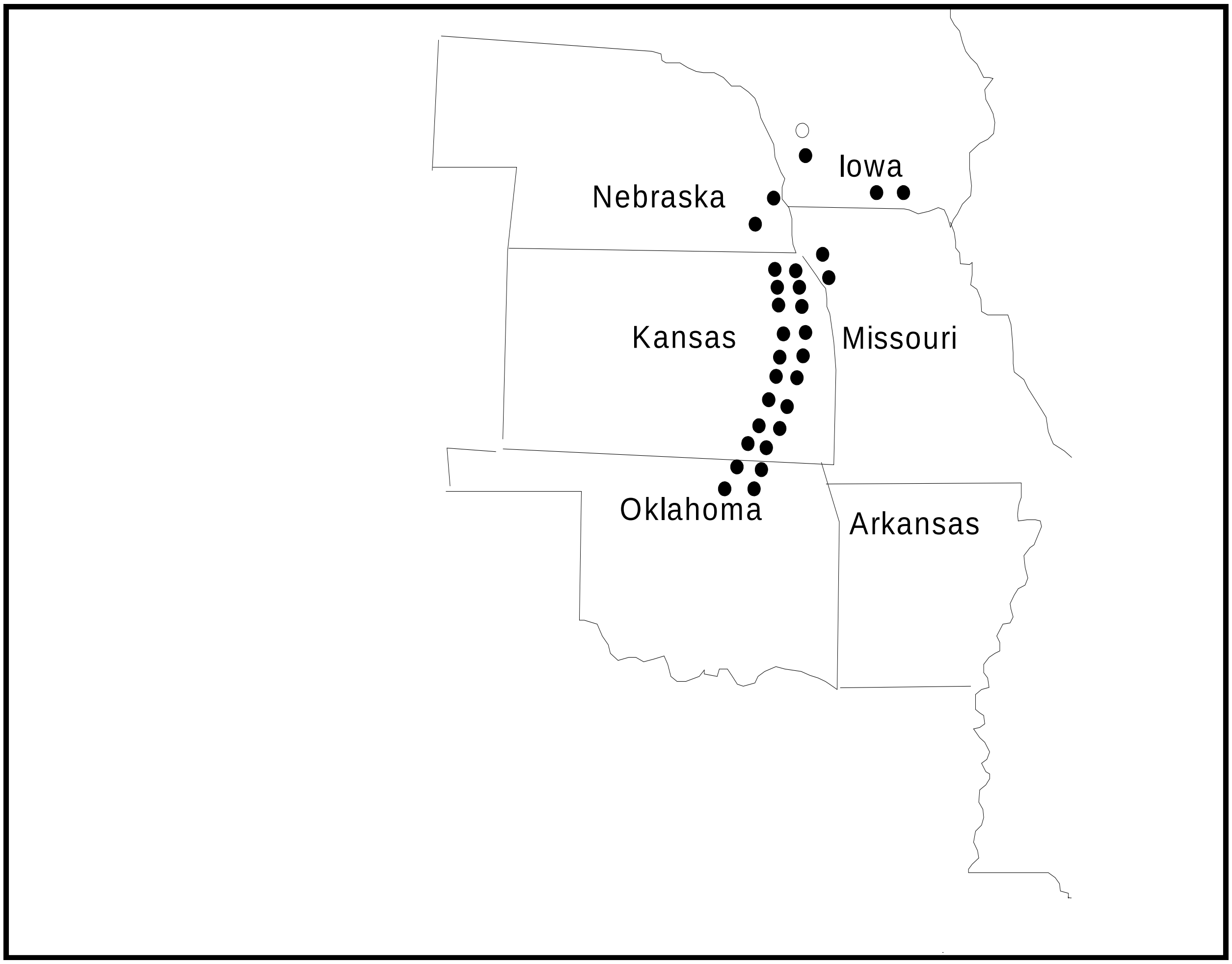
Source: State Hazard Analysis, October 2009

The City of Poplar Bluff, Missouri, was almost wiped out by a tornado on May 9, 1927. This tornado took 92 lives and caused an estimated $2 million in damage. The same day, two severe tornadoes struck St. Louis, Missouri. The first tornado moved across the entire city from the western city limits to the Mississippi River through the Lafayette Park area, killing 306 people in Missouri and Illinois and causing almost $13 million in damage. The second tornado started in the southwestern part of the City and proceeded through the Tower Grove and Vanderventer areas, then on to Granite City, Illinois. Seventy-nine people were killed, and about $23 million in damage resulted from this storm.

On May 20, 1957, an F-5 tornado hit Jackson County causing major damage in the Ruskin Heights area. According to NCDC, the tornado caused 37 deaths, 176 injuries and $2.5 million in damages as it carved a path ranging from one-tenth to nearly one-half mile wide and sped northeast at approximately 42 miles per hour.

During the afternoon and evening of April 3, and the early morning of April 4, 1974, a “super outbreak” of 148 tornadoes across 13 states killed more than 300 people, injured more than 6,000 and caused $600 million in damage (see Figure 3.3.7.5).

Figure 3.3.7.5 - The Tornado Super Outbreaks in 1974



Source: State Hazard Analysis, October 2009

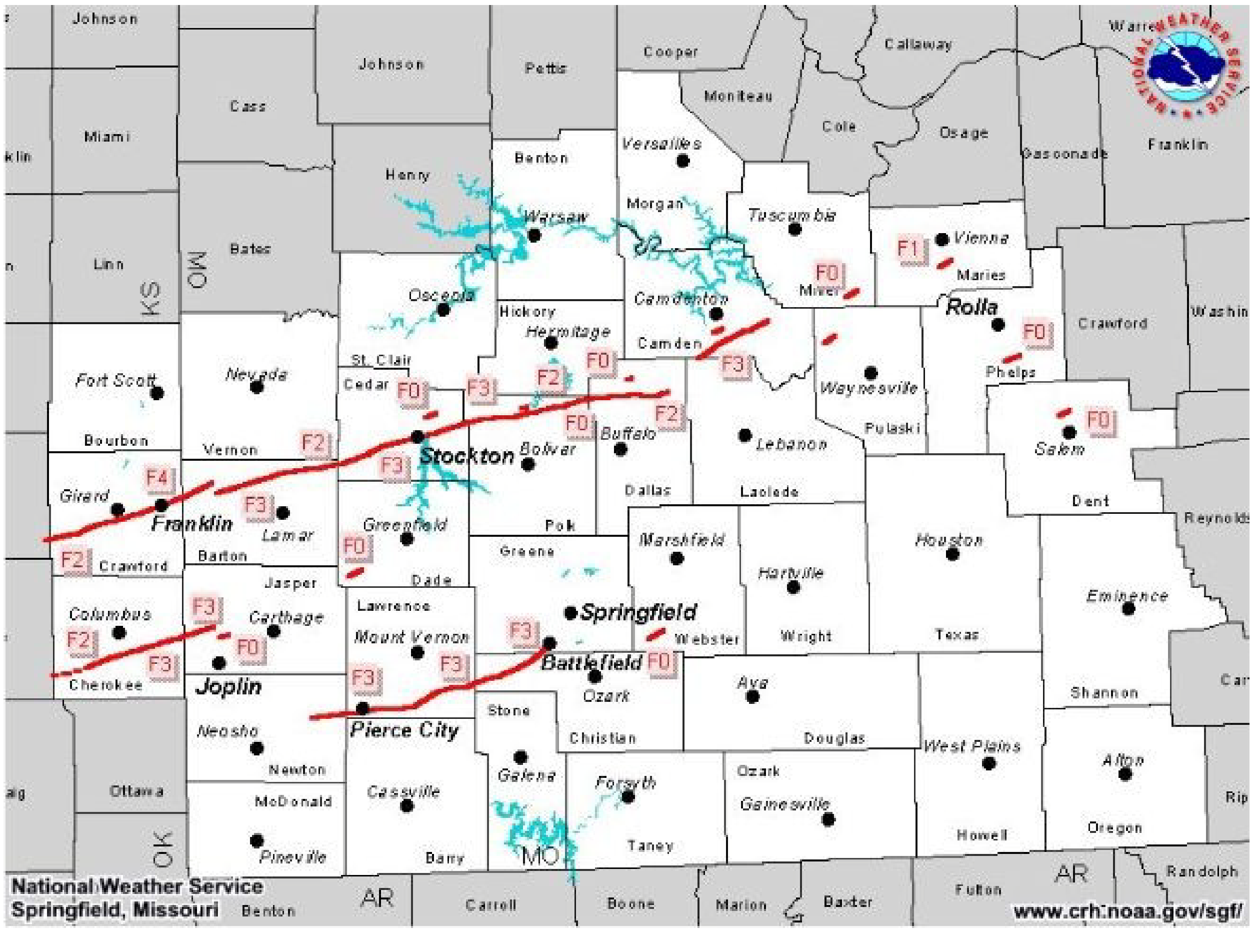
On the afternoon of April 26, and the early morning of April 27, 1991, an outbreak of 54 tornadoes covering six states, including Missouri, resulted in 21 deaths, 308 injuries, and damage exceeding $277 million. There were two deaths in vehicles and 15 deaths in and near mobile homes.

On July 4, 1995, at approximately 5:40 p.m., a tornado struck the Randolph County community of Moberly. The initial touchdown of the storm was south of town. The storm then moved through the eastern half of the community. The tornado uplifted approximately 7 miles northeast of Moberly. At least 15 people were injured, 25 businesses damaged, along with the courthouse, and some 300 families affected. This resulted in a Small Business Administration disaster declaration for low interest loans. The tornado was characterized by the National Weather Service as an F3 tornado.

A record 84 tornadoes were recorded in Missouri in 2003. During the week of May 4, 2003, 79 of those tornadoes occurred, mostly in the southwest portion of Missouri. There were several F4 tornadoes on May 4 in Platte, Clay, and Barton Counties. There were nineteen people killed by the tornadoes in southwest Missouri. That is the highest total since 1959 when 21 were killed. It is only the fourth year in which double-digit deaths from tornadoes occurred in Missouri since 1950. The killer tornadoes all occurred on May 4, 2003 (see Figure 3.3.7.6 and Figure 3.3.7.7). The tornadoes that hit Newton,

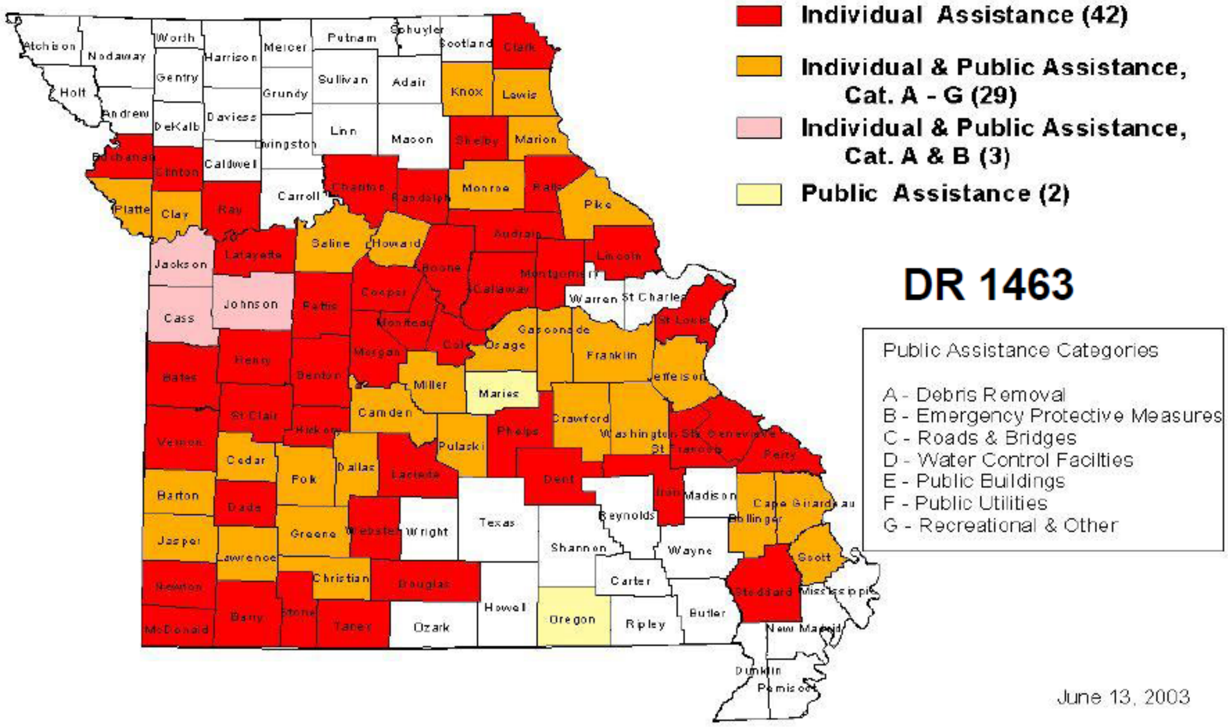
Lawrence, Christian, and Greene Counties killed seven people. Five people were killed by a tornado that hit Cedar and Dallas Counties. A tornado that hit Camden County killed four people, two people died from a tornado in Jasper County, and one person died in Barton County. The tornadoes injured 171 people. That is the highest total since 1957 when 310 people were injured. This information was provided by the National Weather Service.

Figure 3.3.7.6 - Map of the May 4, 2003, Tornadoes



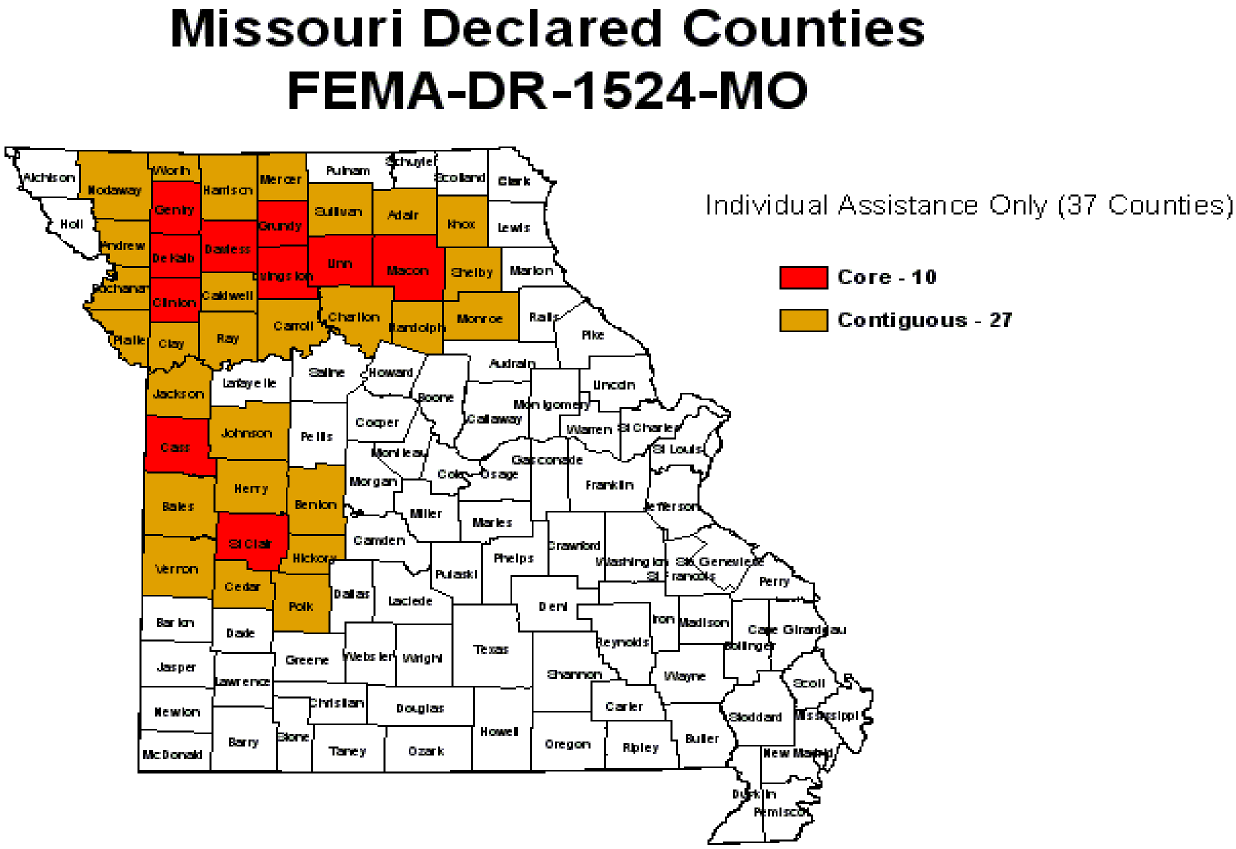
Source: National Weather Service, www.crh.noaa.gov/sgf

Figure 3.3.7.7 - Disaster Assistance by County, May 2003



On May 29, 2004, nine tornadoes touched down in northern and western Missouri (See Figure 3.3.7.8). The strongest, an F4, struck just east of Weatherby in DeKalb County, destroying homes and killing three people.

Figure 3.3.7.8 - Disaster Assistance by County, May 29, 2004



The year 2006 was a record year for tornadoes and severe weather outbreaks for Missouri. 102 tornadoes were recorded which surpassed the previous record year of 2003 when 84 tornadoes were recorded. Four sets of major storms went through the State: March 8–13 (DR 1631), March 30–April 2 (DR 1635), July 19–21 (EM 3267 and DR 1667), and September 22–23 tornado damages.

Between the two March/April storms, which both received declarations for severe storms, tornadoes, and flooding, 44 tornadoes touched down in Missouri. Fourteen people were killed (making it the fifth year in which double-digit deaths from tornadoes occurred in Missouri since 1950), 147 were injured, 646 homes were destroyed, 3,678 homes were damaged, and 1,134 homes were affected. As of June 14, 2006, Missouri citizens had received more than $32 million in federal recovery assistance. As a result of the first round of storms, 41 counties received major disaster declarations (see Figure 3.3.7.8). Also, there was an estimated $5.6 million in damages from these tornadoes reported by four Missouri Electrical Cooperatives. The second round of storms resulted in major disaster declarations for seven counties (see Figure 3.3.7.9). In Pemiscot County, 100 percent of Braggadocio, 80 percent of Deering, and over 60 percent of Caruthersville were destroyed. Major problems included drinking water, utilities, debris removal, and shelter and housing.

Figure 3.3.7.9 - Disaster Assistance by County—March 2006

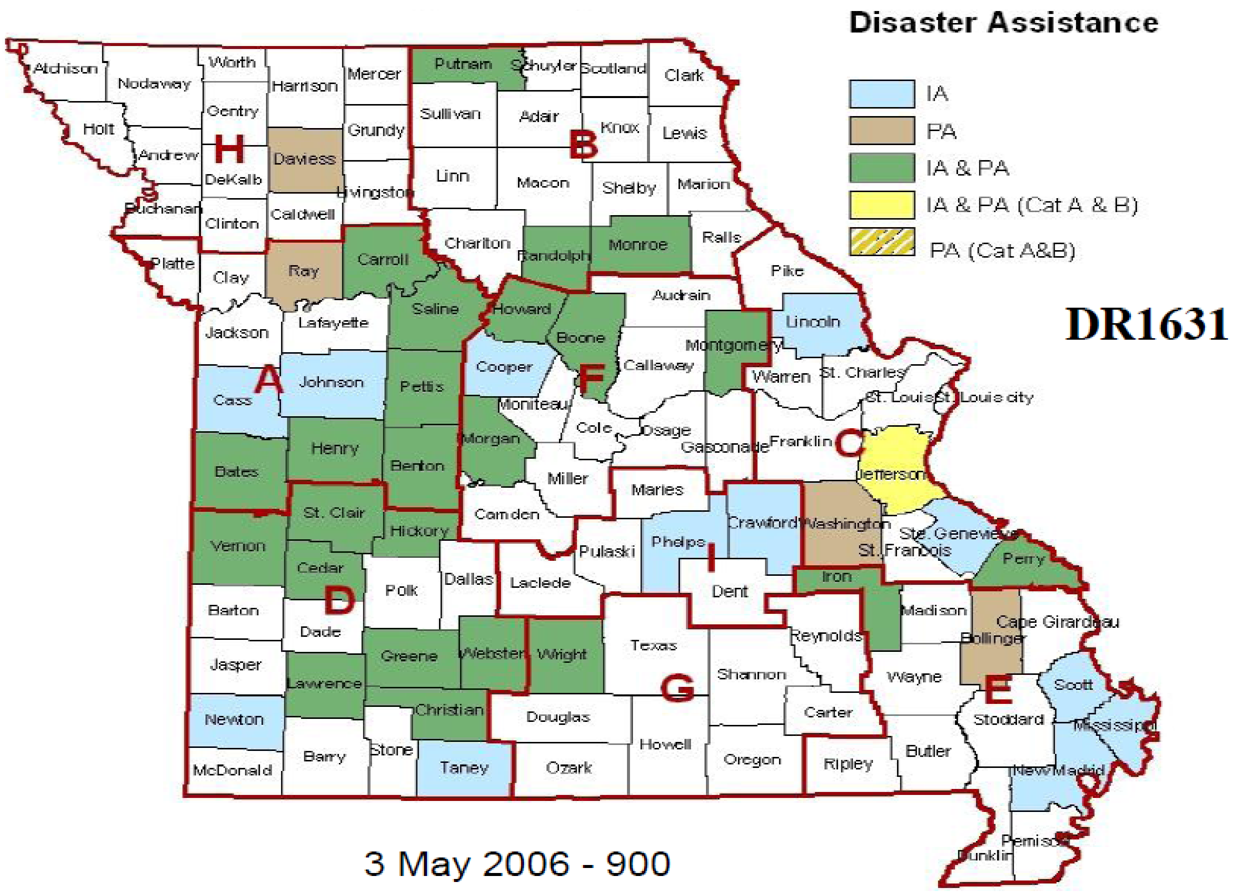
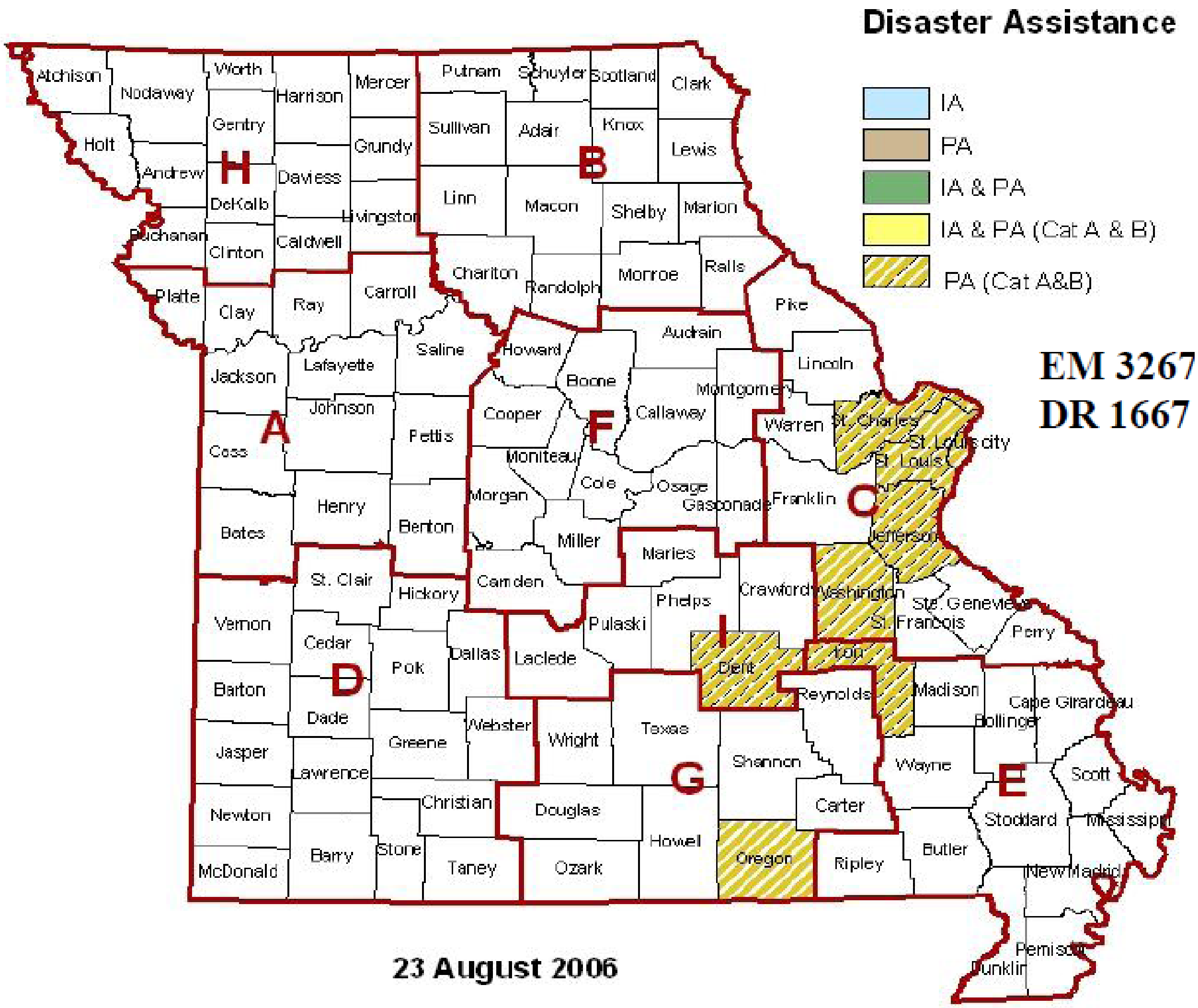


Figure 3.3.7.10 - Disaster Assistance by County—July 2006



On September 22, 2006, another series of severe storms and tornadoes swept across the State and destroyed over 600 residences and 75 businesses in 12 counties. The National Weather Service confirmed an F4 tornado in Perry County. Also, there was an estimated $986,000 in damages reported by nine Missouri Electrical Cooperatives from the tornadoes.

In 2007, there were 45 tornadoes recorded by the NCDC database causing $2.133 million in property damages, three fatalities, and five injuries. There were no federal declarations for tornado damages, but several notable tornadoes. An overnight series of tornadoes started February 28th & continue through the night into March 1st and crossed the State. A total of nine tornadoes did approximately $880,000 damage in Bates, Henry, Cass, Johnson, Monroe, Shelby, Ozark, and Howell Counties.

October 17, 2007—A cold front initiated severe thunderstorms producing isolated tornadoes during the early evening hours through early morning of October 18th. Most of the damage occurred in rural eastern Lawrence County to five houses, a dairy barn, and a saw mill. More damage to homes, trees,

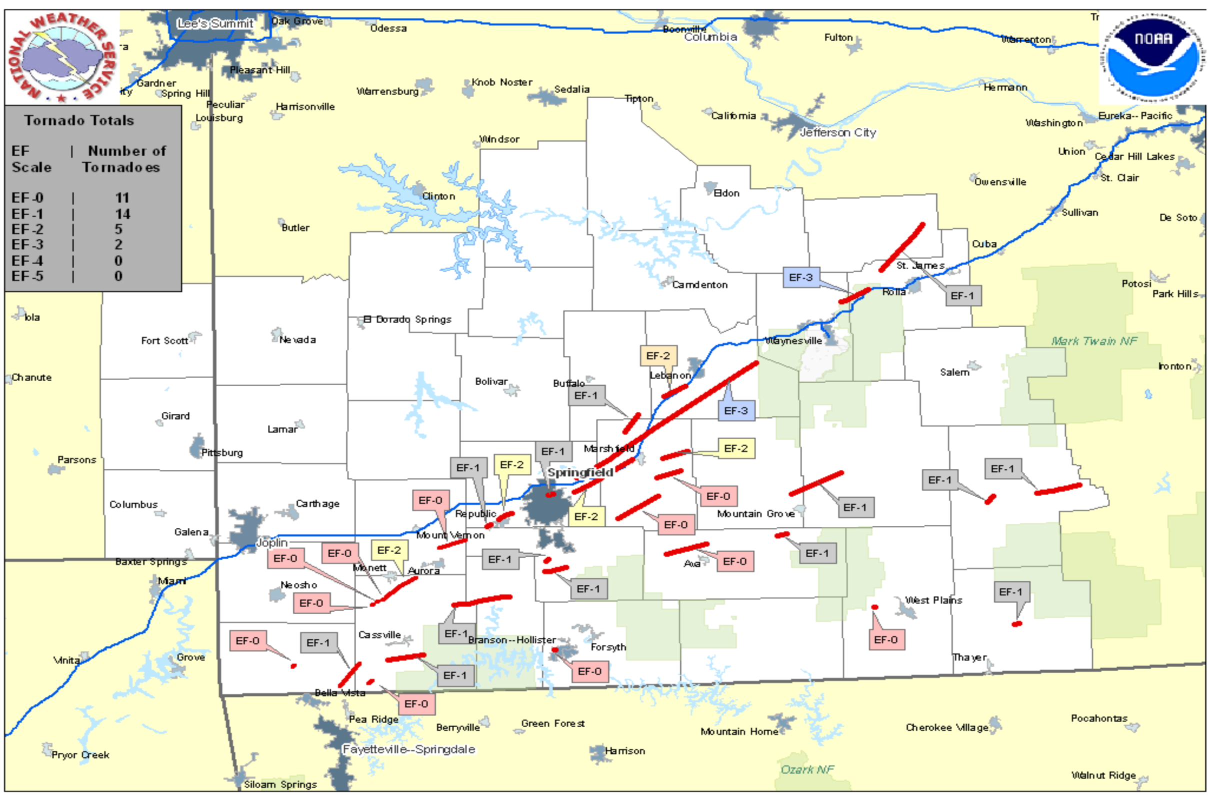
corn crop, and a machine shed were recorded in Greene, Johnson, Laclede, Callaway, and Monroe Counties.

In 2008, there were 103 tornadoes recorded by the NCDC database with 242 injuries, 19 fatalities, $97.9 million in property damages and producing three federal disasters in Missouri.

January 7-8, 2008 (DR-1742 – see Figure 3.3.7.11) Tornado Outbreak--An unusually early severe weather outbreak hit the Missouri Ozarks Monday afternoon, January 7th, into the early morning hours Tuesday, January 8th, 2008. Numerous supercell thunderstorms spawned at least 29 tornadoes that resulted in significant damage to homes, trees and power lines. The supercell thunderstorms were followed by a violent squall line that produced damaging straight line winds in excess of 70 mph. In addition, the storms produced torrential rainfall and flash flooding. The storms developed as an intense storm system tracked out of the Rockies and interacted with an unseasonably warm, moist and unstable airmass across the Ozarks. Figure 3.3.7.11 below shows the paths of the tornado events on January 7-8, 2008.

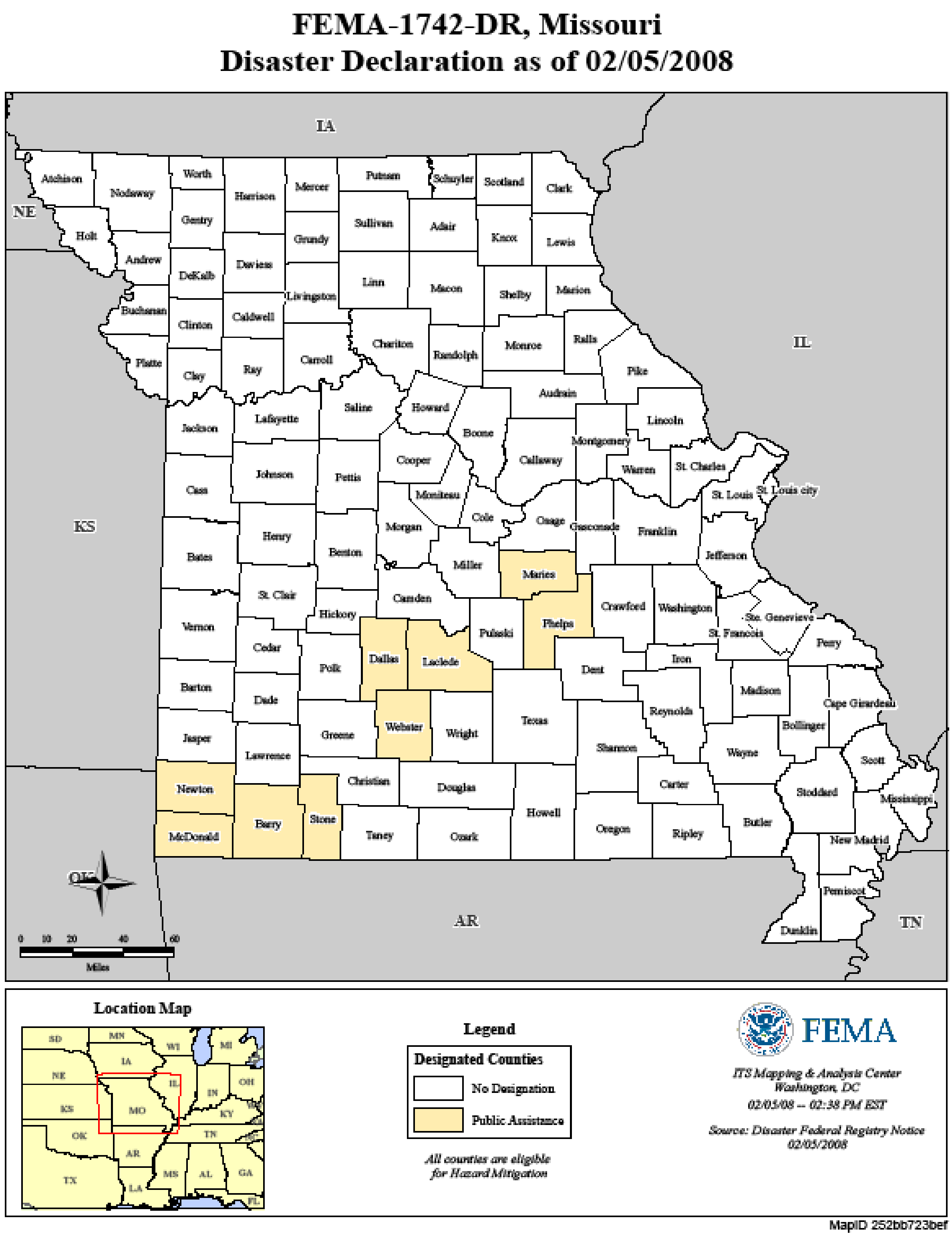
National Weather Service Springfield, Missouri issued 33 severe thunderstorm warnings and 62 tornado warnings in approximately a 12 hour period. A total of 161 severe weather reports were received from mid-afternoon on January 7th through the early morning hours on January 8th.

Figure 3.3.7.11 - Tornado Path on January 7-8, 2008



Source: National Weather Service, www.crh.noaa.gov/sgf

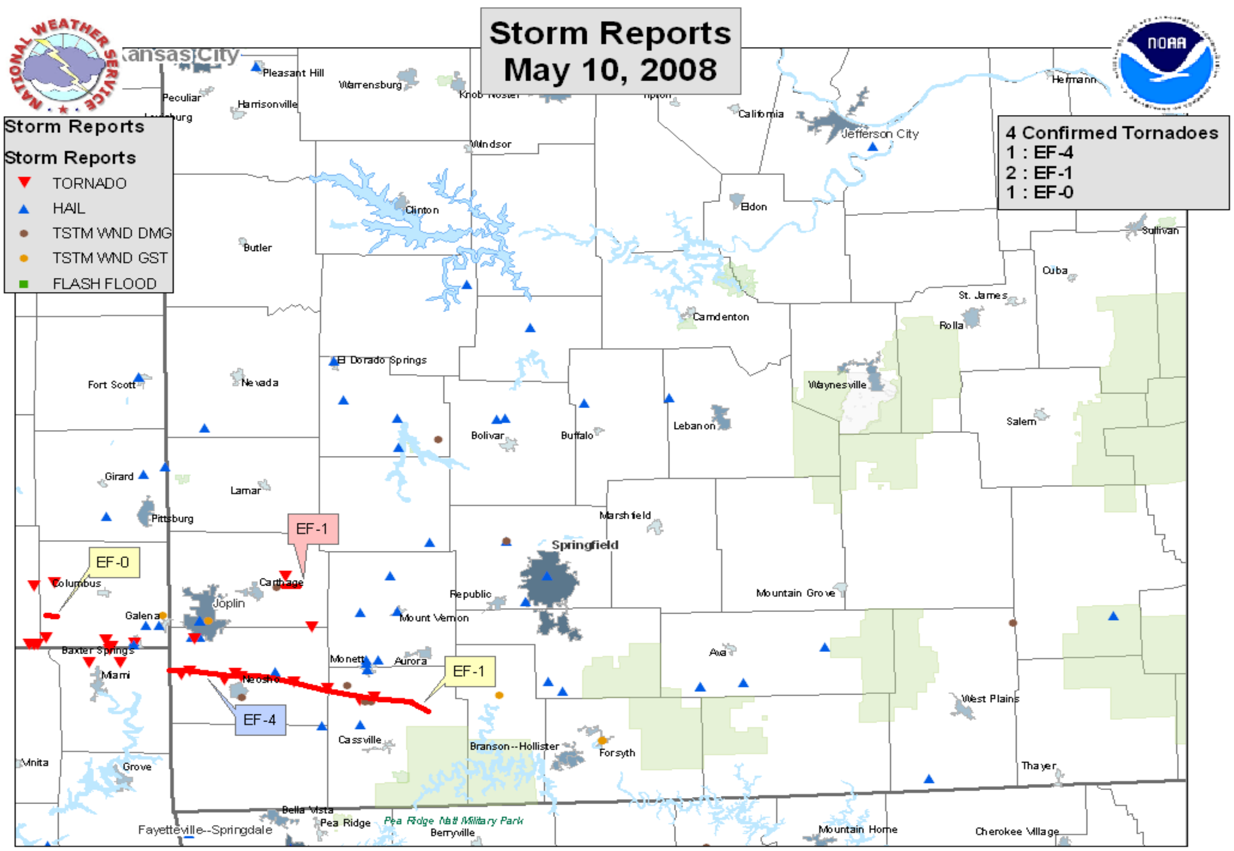
Figure 3.3.7.12 - Disaster Assistance by Counties –February 2008



MAY 10, 2008 (DR-1760 – see Figure 3.3.7.13) --A strong area of low pressure lifted northeast out of southwest Missouri and into central Missouri during the evening. Instability increased over southeast Kansas and the southwest corner of Missouri during the late afternoon as temperatures rose into the mid to upper 70s. The instability along with the strong cold front caused severe thunderstorms to develop. With strong wind shear in the area, the storms in this area quickly became tornadic along with producing large hail to the size of softballs. The storms were mainly concentrated in an area from Cherokee County, Kansas to Newton and Barry Counties in Missouri. Figure 3.3.7.13 below shows the paths of the storm events on January 7-8, 2008.

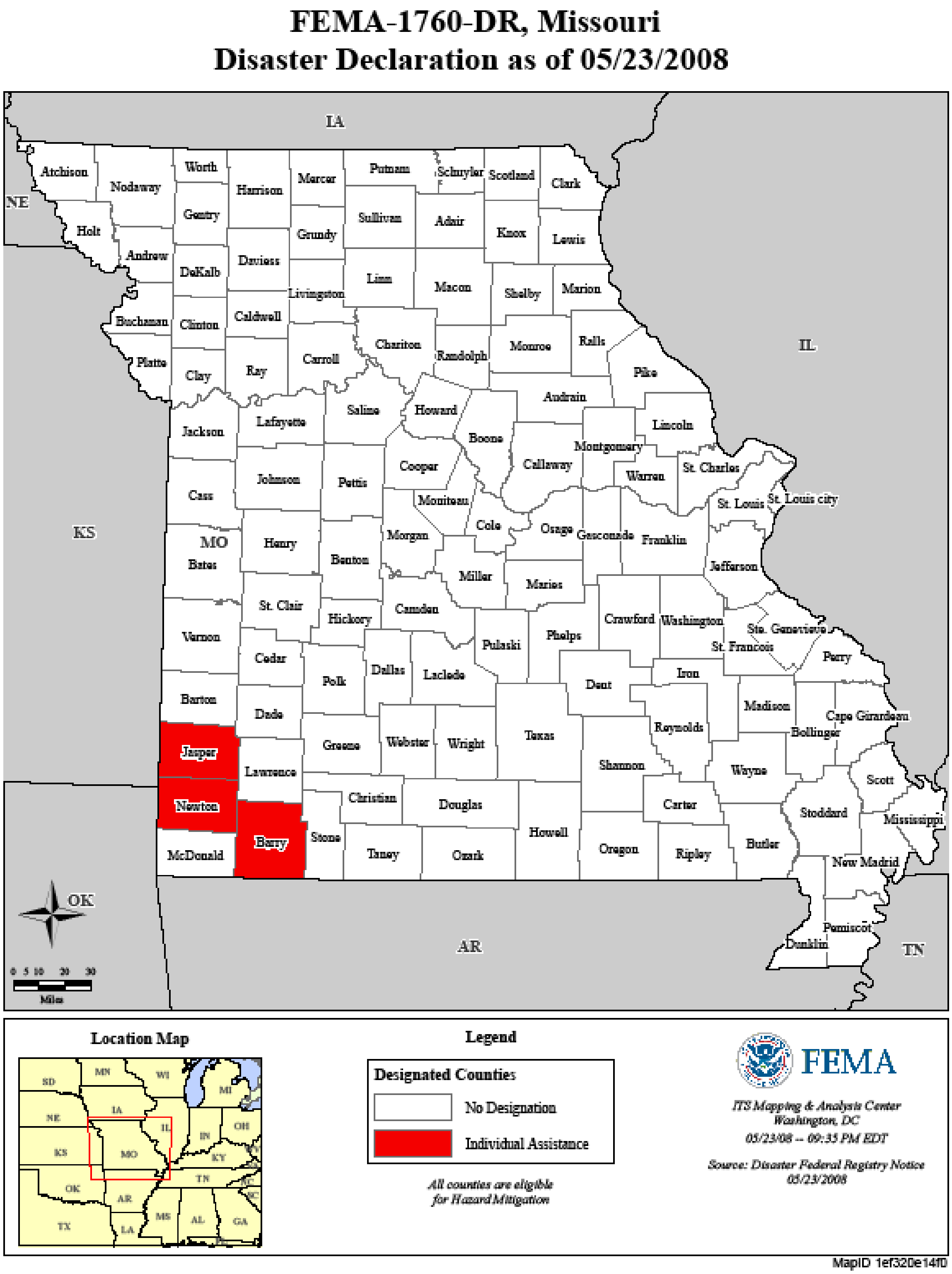
These storms moved into southwest Missouri causing devastating damage to homes, businesses, and trees in Newton, Barry, and Jasper Counties. One tornado, with an intensity that ranged from EF-4 to EF-1, killed 15 people as it tracked through Newton and Barry Counties, while another tornado killed one person in Jasper County. Also, there was $229,100 in estimated damages reported by two Missouri Electrical Cooperatives from the tornadoes.

Figure 3.3.7.13 - Tornado Path on May 10, 2008



Source: National Weather Service, www.crh.noaa.gov/sgf

Figure 3.3.7.14 - Disaster Assistance by Counties-May 2008



There was one additional tornado that produced damages to be included with FEMA-DR-1809. It occurred on November 6, 2008 along the western side of Table Rock Lake near the community of Mano in Barry County. This EF-1 tornado damaged boat docks on Table Rock Lake.

The NCDC database is reporting 50 tornadoes have occurred in Missouri through August 31, 2009. There are 11 injuries, three fatalities, and $18.4 million reported in damages thus far in 2009.

May 13, 2009 (DR-1847 – See Figure 3.3.7.15) --During the evening of May 13, 2009, a series of powerful supercell storms developed ahead of a cold front, pushing southward out of Iowa and Nebraska. These supercell storms produced a wide array of severe weather, with large hail up to the size of golf balls and winds up to 60 mph reported. These storms marched across eastern Kansas and northern Missouri during the evening hours, with a strong supercell storm producing tornadic activity in parts of northeast Missouri. Damage surveys conducted by the National Weather Service, in conjunction with emergency management, have found evidence of three tornadoes in Sullivan and Adair Counties. All tornadoes appeared to have been produced by the same supercell thunderstorm. There were three fatalities. Moderate to severe damage was reported, in the Kirksville area. Also, there was $180,000 in estimated damages reported by three Missouri Electrical Cooperatives from the tornadoes.

May 22, 2011 (DR-1980) – From May 21st through May 26th a massive storm system stretching from Lake Superior southwest to central Texas spawned numerous tornadoes as it swept east across the country. In the late afternoon hours of May 22nd a large, multiple-vortex tornado touched down just outside Joplin, Missouri. The Joplin tornado had recorded wind speeds of greater than 200 mph and had a maximum width of nearly a mile. The twister touched down just east of the Kansas border just north of I-44. It then proceeded to move East and South through the city of Joplin before finally weakening and dissipating near Diamond, Missouri. All told, 158 people were killed and over 1,100 injured making this tornado the deadliest to hit the U.S. since 1947. Some 25% of Joplin had been completely demolished and estimates on insurance claims have been as high as $3 billion making it the single most costly tornado in U.S. history. In addition to the 158 dead in Missouri due to the Joplin tornado, the late may tornado outbreak killed 20 others throughout the states of Arkansas, Kansas, Minnesota, and Oklahoma. The storm system spawned a total of 242 tornados including a second EF-5 that touched down near Calumet, Oklahoma and caused significant damage throughout the Midwestern United States.

Figure 3.3.7.15 - Disaster Assistance by Counties-May 8-16, 2009

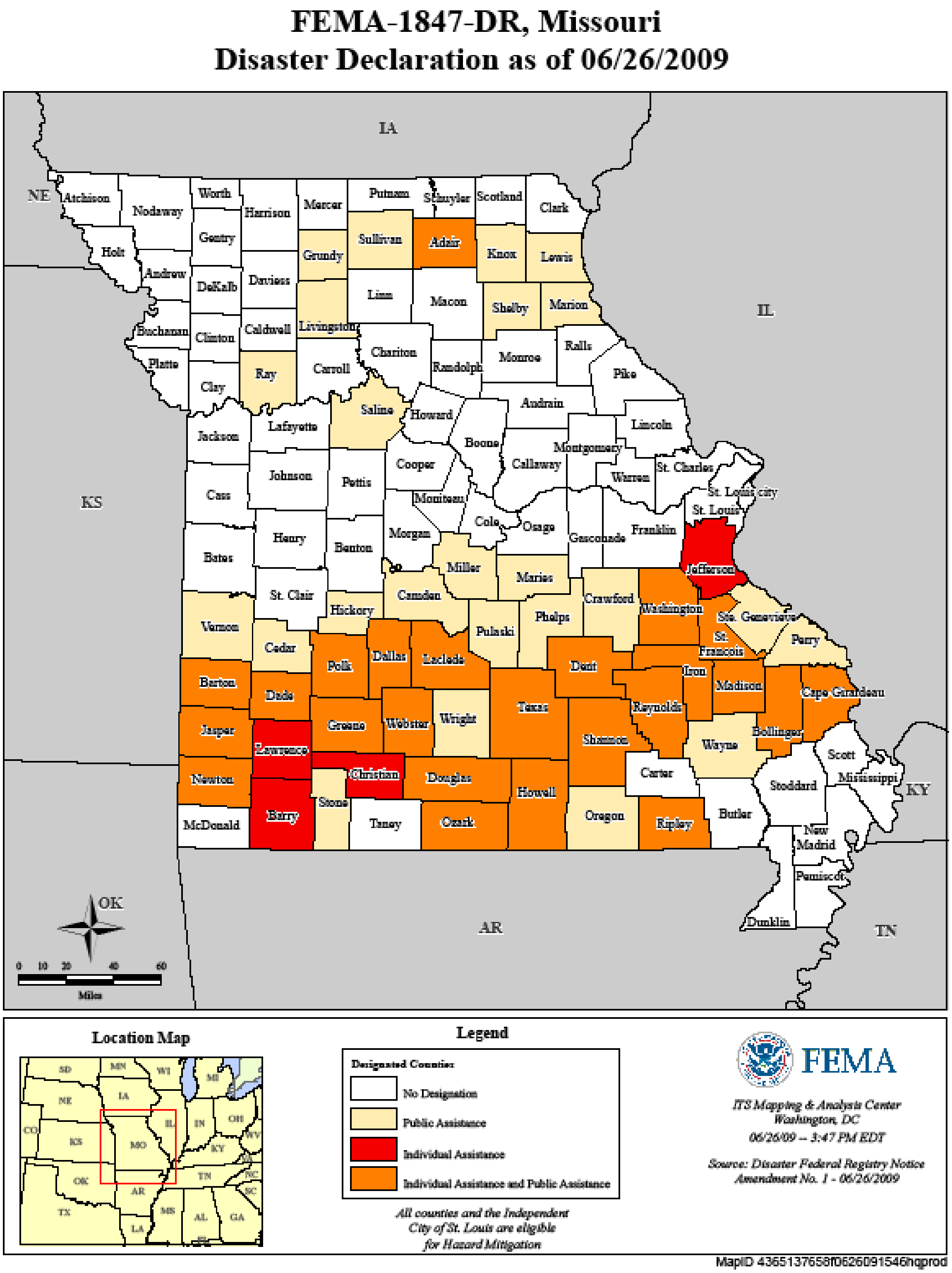


Table 3.3.7d lists Missouri tornado events that resulted in federal disaster declarations since 1975. Table 3.3.7e summarizes Missouri tornado statistics from 1950 through 2009. Figure 3.3.7.16-Figure 3.3.7.19 illustrate Missouri tornadoes and tornado deaths by county.

Table 3.3.7d Disaster Declarations for Missouri Tornado Events Since 1975

Declaration Date	Disaster No.	Incident Type	Counties Declared	Type of Assistance*
May 3, 1975	DR 466	Tornadoes, High Winds, Hail	Caldwell, Newton, Macon, Shelby	PA & IA
May 7, 1977	DR 535	Tornadoes, Flooding	Carroll, Clay, Lafayette, Ray, Cass, Jackson, Pettis	PA & IA
April 21, 1979	DR 579	Tornadoes, Torrential Rain, Flooding	N/A	
May 15, 1980	DR 620	Severe Storms, Tornadoes	Pettis	IA Only
May 1986	N/A	Tornadoes	Scott, Mississippi, Cape Girardeau, Perry	SBA Loans
November 1988	N/A	Tornadoes	St. Charles, Barry	SBA Loans
December 1, 1993	DR 1006	Flooding, Severe Storm, Tornadoes	Bollinger, Butler, Cape Girardeau, Carter, Crawford, Dent, Franklin, Howell, Iron, Jefferson, Madison, Oregon, Perry, Pulaski, Reynolds, Ripley, Shannon, St. Francois, St. Louis, Ste. Genevieve, Stoddard, Texas, Washington, Wayne	IA
			Carter, Dent, Howell, Iron, Madison, Oregon, Perry, Reynolds, Shannon, St. Francois, Ste. Genevieve, Texas, Washington, Wayne	PA
April 21, 1994	DR 1023	Severe Storm, Flooding, Tornadoes	Barry, Callaway, Clay, Cole, Franklin, Jefferson, Lincoln, Morgan, Pemiscot, Phelps, Pulaski, Reynolds, Shannon, St. Charles, St. Louis, Vernon, Washington, St. Louis City	IA
June 2, 1995	DR 1054	Severe Storm, Tornadoes, Hail, Flooding	Adair, Andrew, Atchison, Barry, Barton, Bates, Benton, Boone, Callaway, Camden, Cape Girardeau, Carroll, Cass, Chariton, Clark, Cole, Cooper, Dallas, Daviess, DeKalb, Franklin, Gasconade, Gentry, Henry, Howard, Jackson, Jasper, Jefferson, Johnson, Lafayette, Lewis, Lincoln, Linn, Macon, Maries, McDonald, Mercer, Miller, Mississippi, Moniteau, Montgomery, Morgan, New Madrid, Newton, Nodaway, Osage, Pemiscot, Perry, Ray, Saline, Scotland, Scott, St. Charles, St. Clair, St. Francois, St. Louis, Ste. Genevieve, Stone, Sullivan, Vernon, Warren, St. Louis City	IA

Declaration Date	Disaster No.	Incident Type	Counties Declared	Type of Assistance*
			Andrew, Atchison, Barry, Bates, Benton, Boone, Callaway, Cape Girardeau, Carroll, Chariton, Clark, Cole, Cooper, Daviess, DeKalb, Franklin, Gasconade, Gentry, Henry, Howard, Jefferson, Johnson, Lafayette, Linn, Macon, McDonald, Mercer, Miller, Mississippi, Moniteau, Montgomery, Nodaway, Perry, Ray, Saline, St. Charles, St. Clair, St. Louis, Ste. Genevieve, Stone, Sullivan, Vernon, Warren	PA
July 1995	N/A	Tornadoes	Randolph, (City of Moberly)	SBA Loans
May 6, 2002	DR 1412	Severe Storms and Tornadoes	Barry, Barton, Bollinger, Butler, Camden, Cape Girardeau, Carter, Cedar, Christian, Crawford, Dade, Dallas, Dent, Douglas, Dunklin, Greene, Hickory, Howell, Iron, Jasper, Jefferson, Laclede, Lawrence, Madison, McDonald, Mississippi, New Madrid, Newton, Oregon, Ozark, Pemiscot, Perry, Polk, Reynolds, Ripley, Scott, Shannon, St. Francois, St. Genevieve, Stoddard, Stone, Taney, Texas, Vernon, Washington, Wayne, Webster, Wright	IA
			Adair, Barry, Barton, Bollinger, Boone, Butler, Camden, Cape Girardeau, Carroll, Carter, Cedar, Chariton, Christian, Clark, Cooper, Crawford, Dade, Dallas, DeKalb, Dent, Douglas, Grundy, Howard, Howell, Iron, Johnson, Knox, Laclede, Lafayette, Lawrence, Lewis, Lincoln, Linn, Livingston, Macon, Madison, Maries, Marion, McDonald, Mercer, Miller, Mississippi, Oregon, Osage, Ozark, Pemiscot, Perry, Phelps, Pike, Polk, Pulaski, Ralls, Ray, Reynolds, Ripley, Schuyler, Scotland, Scott, Shannon, Shelby, Ste. Genevieve, Stoddard, Stone, Sullivan, Taney, Texas, Vernon, Wayne, Webster, Wright	PA
May 6, 2003	DR 1463	Severe Storms, Tornadoes, and Flooding	Barry, Barton, Bates, Benton, Bollinger, Buchanan, Camden, Cape, Cass, Cedar, Christian, Clay, Clinton, Cooper, Crawford, Dade, Dallas, Dent, Douglas, Franklin, Knox, Gasconade, Girardeau, Greene, Henry, Hickory, Iron, Jackson, Jasper, Jefferson, Johnson, Laclede, Lafayette, Lawrence, McDonald, Miller, Monroe, Morgan, Newton, Osage, Perry Pettis, Phelps, Platte, Polk, Pulaski, Ray, St. Francois, St. Louis, Ste. Genevieve, Saline, Scott, St. Clair, Stoddard, Stone, Taney, Vernon, Washington, Webster	IA
			Bollinger, Crawford, Franklin, Gasconade, Knox, Maries, Miller, Oregon, Osage, Pulaski, Washington	PA

Declaration Date	Disaster No.	Incident Type	Counties Declared	Type of Assistance*
June 11, 2004	DR 1524	Severe Storms, Tornadoes, and Flooding	Adair, Andrew, Bates, Benton, Caldwell, Carroll, Cass, Cedar, Chariton, Clay, Clinton, Daviess, DeKalb, Gentry, Grundy, Harrison, Henry, Hickory, Jackson, Johnson, Knox, Linn, Livingston, Macon, Mercer, Monroe, Nodaway, Platte, Polk, Randolph, Ray, Shelby, St. Clair, Sullivan, Vernon, Worth	IA
March 16, 2006	DR 1631	Severe Storms, Tornadoes, and Flooding	Bates, Benton, Boone, Carroll, Cass, Cedar, Christian, Cooper, Crawford, Greene, Henry, Hickory, Howard, Iron, Jefferson, Johnson, Lawrence, Lincoln, Mississippi, Monroe, Montgomery, Morgan, New Madrid, Newton, Perry, Pettis, Phelps, Putnam, Randolph, St. Clair, Ste. Genevieve, Scott, Saline, Taney, Vernon, Webster, Wright	IA
			Bates, Bollinger, Benton, Boone, Carroll, Cedar, Christian, Daviess, Greene, Henry, Hickory, Howard, Iron, Lawrence, Monroe, Montgomery, Morgan, Perry, Pettis, Putnam, Randolph, Ray, Saline, St. Clair, Vernon, Washington, Webster, Wright	PA
April 5, 2006	DR 1635	Severe Storms, Tornadoes, and Flooding	Andrew, Butler, Dunklin, Pemiscot, St. Francois, Stoddard	IA
			Andrew, Jefferson, Pemiscot, Pettis, St. Francois	PA
February 5, 2008	DR 1742	Severe Storms, Tornadoes, and Flooding	Barry, Dallas, Laclede, Maries, McDonald, Newton, Phelps, Stone, Webster	PA
May 23, 2008	DR 1760	Severe Storms, & Tornadoes	Barry, Jasper, Newton	IA
November 13, 2008	DR 1809	Severe Storms, Flooding & a Tornado	Adair, Audrain, Barry, Bollinger, Boone, Butler, Callaway, Cape Girardeau, Carter, Chariton, Christian, Clark, Crawford, Dent, Douglas, Dunklin, Howard, Howell, Jefferson, Knox, Lewis, Lincoln, Linn, Madison, Maries, Marion, Miller, Mississippi, Montgomery, New Madrid, Oregon, Osage, Ozark, Perry, Ralls, Randolph, Ray, Reynolds, Ripley, Schuyler, Scotland, Scott, Shannon, Shelby, St. Charles, St, Louis, Ste. Genevieve, Stoddard, Stone, Sullivan, Taney, Texas, Wayne, Webster, Wright and Independent City of St Louis.	IA & PA (not all counties list have IA & PA assistance)

Declaration Date	Disaster No.	Incident Type	Counties Declared	Type of Assistance*
June 19, 2009	DR 1847	Severe Storms, Tornadoes & Flooding	Adair, Barry, Barton, Bollinger, Camden, Cape Girardeau, Christian, Cedar, Crawford, Dade, Dallas, Dent, Douglas, Greene, Hickory, Howell, Iron, Jackson, Jasper, Knox, Laclede, Lawrence, Lewis, Madison, Maries, Marion, Miller, Newton, Oregon, Ozark, Perry, Phelps, Polk, Pulaski, Ray, Reynolds, Ripley, St. Francois, Ste. Genevieve, Saline, Shannon, Shelby, Stone, Sullivan, Texas, Vernon, Washington, Wayne, Webster, Wright	IA & PA (not all counties list have IA & PA assistance)
August 17, 2010	DR 1934	Severe Storms, Flooding, and Tornadoes	Adair County, Barton County, Bollinger County, Camden County, Cape Girardeau County, Cedar County, Crawford County, Dade County, Dallas County, Dent County, Douglas County, Greene County, Grundy County, Hickory County, Howell County, Iron County, Jasper County, Knox County, Laclede County, Lewis County, Livingston County, Madison County, Maries County, Marion County, Miller County, Newton County, Oregon County, Ozark County, Perry County, Phelps County, Polk County, Pulaski County, Ray County, Reynolds County, Ripley County, Saint Francois County, Sainte Genevieve County, Saline County, Shannon County, Shelby County, Stone County, Sullivan County, Texas County, Vernon County, Washington County, Wayne County, Webster County and Wright County	IA & PA (not all counties listed have IA & PA assistance)
May 22, 2011	DR 1980	Severe Storms, Flooding, and Tornadoes	Barry County, Bollinger County, Butler County, Cape Girardeau County, Carter County, Christian County, Douglas County, Dunklin County, Howell County, Iron County, Jasper County, Madison County, McDonald County, Miller County, Mississippi County, New Madrid County, Newton County, Oregon County, Ozark County, Pemiscot County, Perry County, Pettis County, Polk County, Reynolds County, Ripley County, Saint Francois County, Saint Louis County, Sainte Genevieve County, Scott County, Shannon County, Stoddard County, Stone County, Taney County, Texas County, Washington County, Wayne County, Webster County and Wright County	IA & PA (not all counties listed have IA & PA assistance)
August 22, 2011	DR 4012	Severe Storms, Flooding and Tornadoes	Atchison County, Holt County, Andrew County, Buchanan County, Platte County, Lafayette County, Ray County, Carroll County, Saline County, Howard County, Cooper County	IA & PA (not all counties listed have IA & PA)

Source: Federal Emergency Management Agency, State Emergency Management Agency
Note:
*IA denotes Individual Assistance; PA denotes Public Assistance, SBA denotes Small Business Administration

Table 3.3.7e Missouri Tornado Statistics, 1950–2012

Total Number of Tornadoes	2,159
Total Number of Deaths	380
Total Number of Injuries	4,174
Yearly Average of Tornadoes	35
Yearly Average of Deaths	6
Yearly Average of Injuries	67

Figure 3.3.7.16 - Missouri Tornadoes by County: Top Twenty-Five, 1950–July 31, 2009

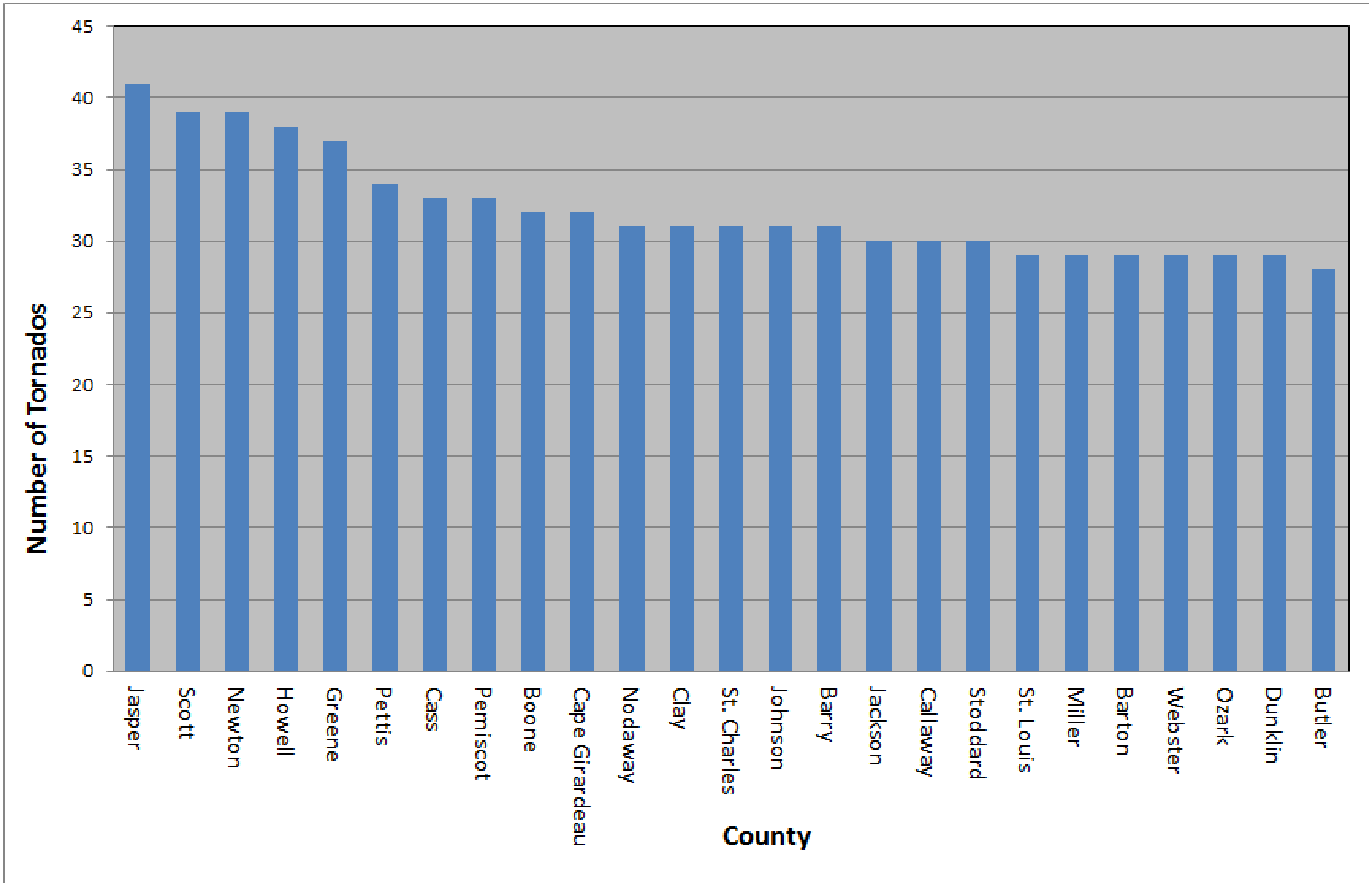


Figure 3.3.7.17 - Missouri Tornadoes by County, 1950–March 17, 2012

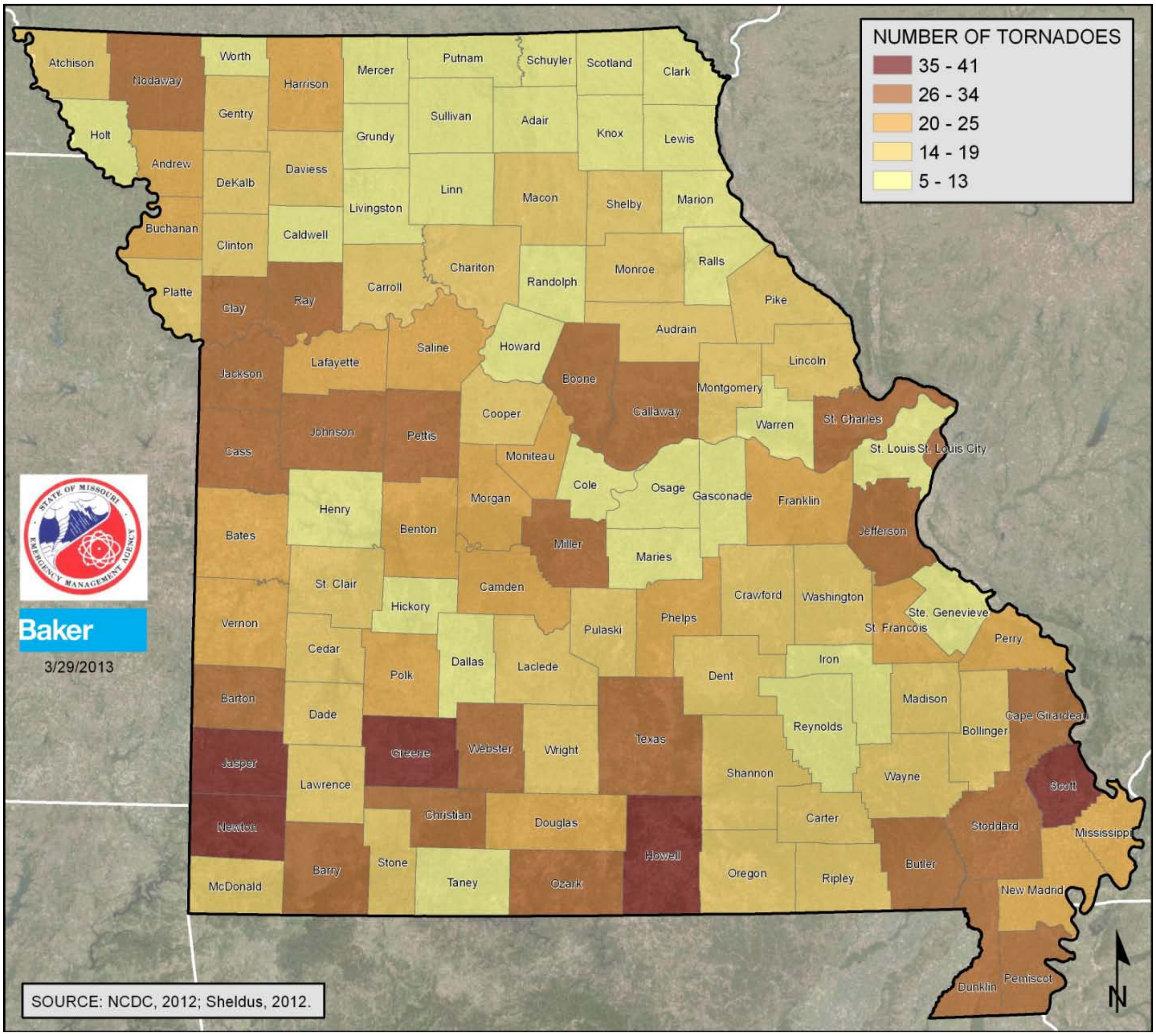


Figure 3.3.7.18 - Missouri Tornado Deaths by County: Top Ten, 1950–2012

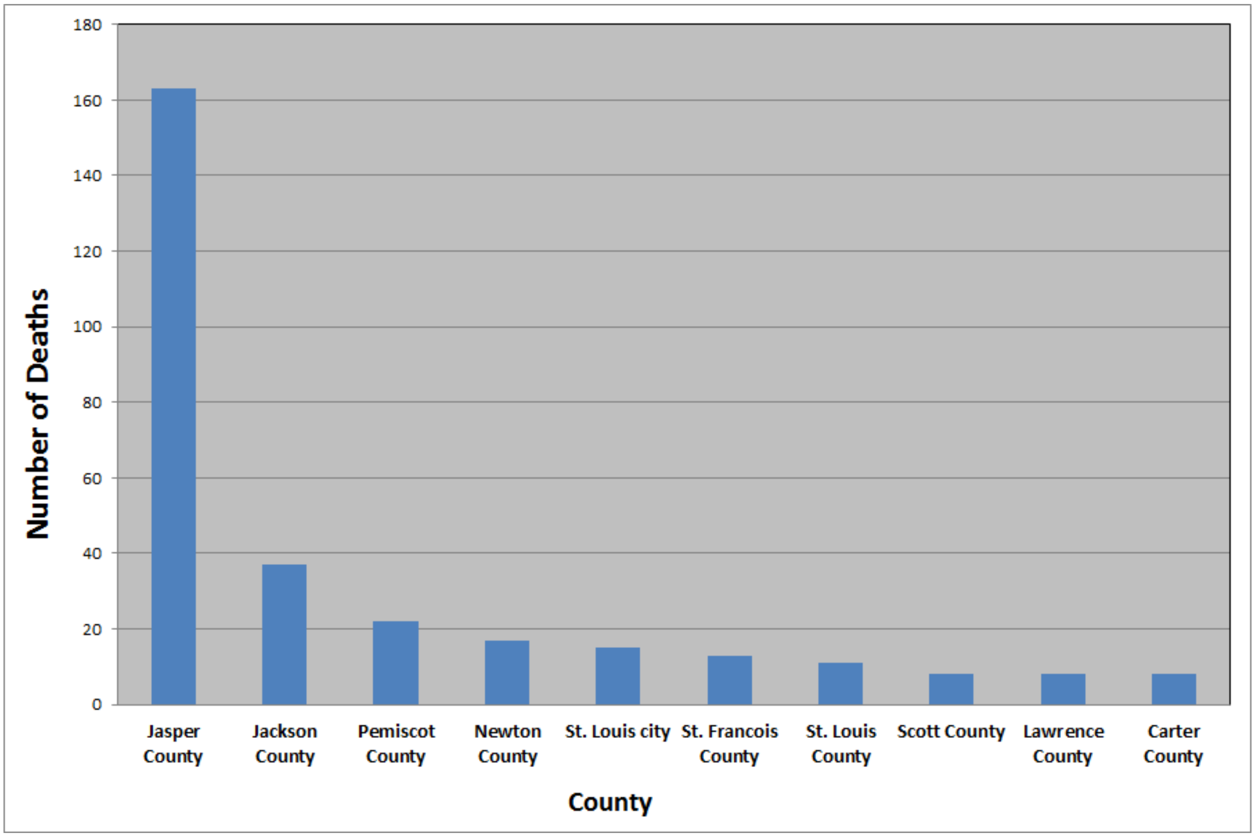
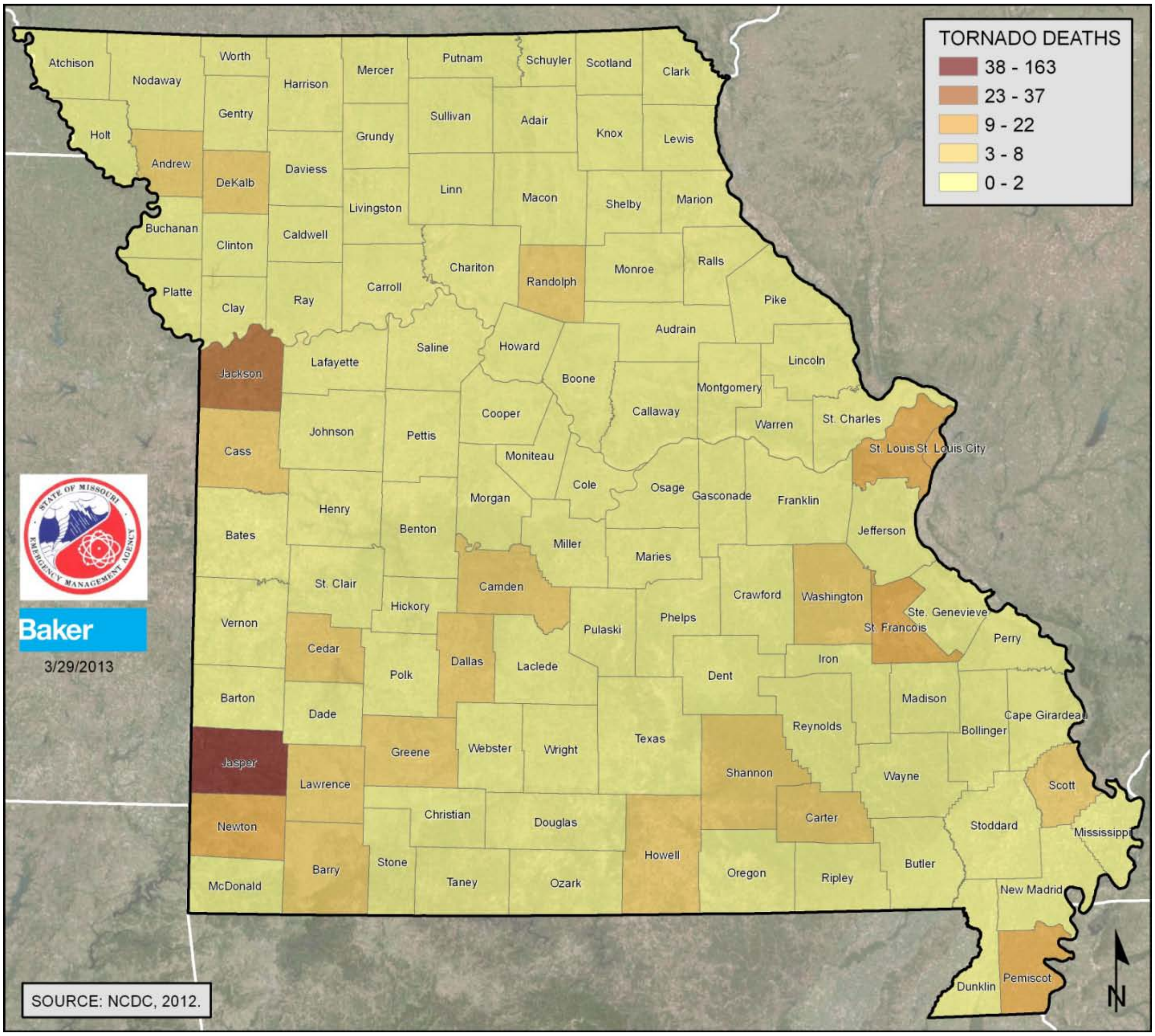


Figure 3.3.7.19 - Missouri Tornado Deaths by County, 1950– March 17, 2012



According to the USDA Risk Management Agency, insured crop losses throughout the State of Missouri as a result of tornado damages for the eleven year period of 1998 – 2008 totaled $28,492. A detailed listing of insured crop losses by crop, county, and, year for insured crop losses is provided at the following link: USDA Risk Management Agency Crop Claims Data.

Measure of Probability and Severity

Probability: High

Severity: High

The United States has 10 times more tornadoes than any other nation in the world. Missouri averages 36 tornadoes per year and has recorded 2.119 tornadoes between 1950 and July 31, 2009. Missourians have a high probability that tornadoes will continue to affect their lives. The natural phenomena that create tornadoes will continue to occur beyond the ability to control them.

Every tornado is a potential killer, and many are capable of great destruction. Tornadoes can topple buildings, roll mobile homes, uproot trees, hurl people and animals through the air for hundreds of yards, and fill the air with lethal, windblown debris. Sticks, glass, roofing material, and lawn furniture all become deadly missiles when driven by tornado winds. In 1975, a Mississippi tornado carried a home freezer for more than a mile. Once, a tornado in Broken Bow, Oklahoma, carried a motel sign 30 miles and dropped it in Arkansas. Tornadoes do their destructive work through the combined action of their strong rotary winds and the impact of windblown debris. In the simplest case, the force of the tornado's winds pushes the windward wall of a building inward. The roof is lifted up, and the other walls fall outward. Until recently, this damage pattern led to the incorrect belief that the structure had exploded as a result of the atmospheric pressure drop associated with the tornado.

The information in Table 3.3.7f is from the Impact Analysis of Potential for Detrimental Impacts of Hazards done for the Emergency Management Accreditation Program.

Table 3.3.7f EMAP Impact Analysis: Tornadoes

Subject	Detrimental Impacts
Health and Safety of Persons in the Area at Time of Incident	Localized impact expected to be severe for incident areas and moderate to light for other adversely affected areas.
Health and Safety of Personnel Responding to the Incident	Localized impact expected to limit damage to personnel in the areas at the time of the incident.
Continuity of Operations	Damage to facilities/personnel in the area of the incident may require temporary relocation of some operations.
Property, Facilities, and Infrastructure	Localized impact to facilities and infrastructure in the area of the incident. Some severe damage possible.
Delivery of Services	Localized disruption of roads, facilities, and/or utilities caused by incident may postpone delivery of some services.
The Environment	Localized impact expected to be severe for incident areas and moderate to light for other areas affected by the storm or HazMat spills.
Economic and Financial Condition	Local economy and finances adversely affected, possibly for an extended period of time.
Regulatory and Contractual Obligations	Regulatory waivers may be needed locally. Fulfillment of some contracts may be difficult. Impact may temporarily reduce deliveries.
Reputation of or Confidence in the Entity	Ability to respond and recover may be questioned and challenged if planning, response, and recovery not timely and effective.

Synopsis

The enormous power and destructive capability of tornadoes are beyond mankind's capabilities to control. The potential severity of effects from tornadoes will continue to be high. We will continue to experience deaths, injuries, and property damage from tornadoes. However, technological advances will facilitate earlier warnings than previously available. This, combined with a vigorous public education program and improved construction techniques, provides the potential for significant reductions in the number of deaths and injuries, as well as reduced property damage.

For additional information on vulnerability to tornadoes, see Section 3.5.7.

3.3.8 Severe Winter Weather/Snow/Ice/Severe Cold

Description of Hazard

Severe winter weather, including snowstorms, ice storms, and extreme cold, can affect any area of Missouri. The greatest threat is likely to occur in the area north of the Missouri River, as with the devastating Kansas City area ice storm on January 31, 2002, which stretched into central Missouri and led to a presidential disaster declaration (DR 1403).

Severe weather, such as snow, ice storms, and extreme cold can cause injuries, deaths, and property damage in a variety of ways. Winter storms are considered deceptive killers. This is because most deaths are indirectly related to the storm. Causes of death range from traffic accidents due to adverse driving conditions such as icy roads, to heart attacks caused by overexertion while shoveling snow and from other related activities. Hypothermia or frostbite may be considered the most direct cause of death and injury that can be attributed to winter storms or severe cold.

Economic costs are also difficult to measure. Heavy accumulations of ice can bring down trees, electric power lines and poles, telephone lines, and communications towers Power outages create an increased risk of fire, as home occupants use alternative fuel sources (wood, kerosene, etc.) for heat and fuel-burning lanterns or candles for emergency lighting). These storms can also affect utility and city operations due to debris removal and landfill hauling. In the 2002 ice storm, one home burned when ice-laden tree limbs fell and tore the electrical junction box from the outside of the home. Electrical sparks ignited a blaze that destroyed the home.

Figure 3.3.8.1 - Damaged poles in Poplar Bluff, MO, January 2009

Photo courtesy of SEMA

Crops and trees can be damaged, and livestock can be killed or injured due to deep snow, ice, or severe cold. Buildings and automobiles may be damaged from falling tree limbs, power lines, and poles. Local governments, home and business owners, and power companies were faced with spending millions of dollars to restore services, remove debris, and haul debris. Federal Public Assistance for local

governments and Individual Assistance for citizens and businesses under helped cover much of the expense.

The types of watches and warnings during severe winter weather are listed below:

- **Winter Weather Advisory**—Winter weather conditions are expected to cause significant inconveniences and may be hazardous. If caution is exercised, these situations should not become life threatening. Often the greatest hazard is to motorists.
- **Winter Storm Watch**—Severe winter conditions, such as heavy snow and/or ice are possible within the next day or two.
- **Winter Storm Warning**—Severe winter conditions have begun or are about to begin.
- **Blizzard Warning**—Snow and strong winds will combine to produce a blinding snow (near zero visibility), deep drifts, and life-threatening wind chill.
- **Ice Storm Warning--**Dangerous accumulations of ice are expected with generally over one quarter inch of ice on exposed surfaces. Travel is impacted and widespread downed trees and power lines often result.
- **Wind Chill Advisory**—Combination of low temperatures and strong winds will result in wind chill readings of -20 degrees F or lower.
- **Wind Chill Warning**—Wind chill temperatures of -35 degrees F or lower are expected. This is a life threatening situation.

Wind Chill Chart: In 2001, the National Weather Service (NWS) implemented a replacement Wind Chill Temperature (WCT) index for the 2001–2002 winter season (see Figure 3.3.8.2). The reason for the change was to improve the current WCT index used by the NWS and the Meteorological Services of Canada (the Canadian equivalent of the NWS), which was based on scientific research and a previous index from 1945.

Figure 3.3.8.2 - Wind Chill Chart

Wind Chill Chart

Temperature (°F)

Wind (mph) \ Calm	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
5	36	31	25	19	13	7	1	-5	-11	-16	-22	-28	-34	-40	-46	-52	-57	-63
10	34	27	21	15	9	3	-4	-10	-16	-22	-28	-35	-41	-47	-53	-59	-66	-72
15	32	25	19	13	6	0	-7	-13	-19	-26	-32	-39	-45	-51	-58	-64	-71	-77
20	30	24	17	11	4	-2	-9	-15	-22	-29	-35	-42	-48	-55	-61	-68	-74	-81
25	29	23	16	9	3	-4	-11	-17	-24	-31	-37	-44	-51	-58	-64	-71	-78	-84
30	28	22	15	8	1	-5	-12	-19	-26	-33	-39	-46	-53	-60	-67	-73	-80	-87
35	28	21	14	7	0	-7	-14	-21	-27	-34	-41	-48	-55	-62	-69	-76	-82	-89
40	27	20	13	6	-1	-8	-15	-22	-29	-36	-43	-50	-57	-64	-71	-78	-84	-91
45	26	19	12	5	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79	-86	-93
50	26	19	12	4	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81	-88	-95
55	25	18	11	4	-3	-11	-18	-25	-32	-39	-46	-54	-61	-68	-75	-82	-89	-97
60	25	17	10	3	-4	-11	-19	-26	-33	-40	-48	-55	-62	-69	-76	-84	-91	-98

Frostbite Times: 30 minutes, 10 minutes, 5 minutes

$$\text{Wind Chill (°F)} = 35.74 + 0.6215T - 35.75(V^{0.16}) + 0.4275T(V^{0.16})$$

Where, T= Air Temperature (°F) V= Wind Speed (mph)

Effective 11/01/01

Source: National Weather Service

This formula makes use of advances in science, technology, and computer modeling to provide a more accurate, understandable, and useful formula for calculating the dangers from winter winds and freezing temperatures. In addition, clinical trials have been conducted, and the results of those trials have been used to verify and improve the accuracy of the new formula. The replacement WCT index:

- Uses wind speed calculated at the average height of the human body's face (5 feet), instead of the standard anemometer height (33 feet);
- Is based on a human face model;
- Incorporates modern heat transfer theory (heat loss from the body to its surroundings during cold and breezy/windy days);
- Lowers the calm wind threshold to 3 miles per hour;
- Uses a consistent standard for skin tissue resistance; and
- Assumes the worst-case scenario for solar radiation (clear night sky).

Historical Statistics

Weather data indicate that the Missouri counties north of the Missouri River receive an average annual snowfall of 18 to 22 inches. Counties south of the Missouri River receive an annual average of 8 to 12 inches. The events that involve borderline conditions of freezing rain and ice are highly unpredictable. The durations of the more serious events combined with other factors, such as high winds, are also highly unpredictable. The degree of severity may be localized to a small area due to a combination of climatic conditions.

Besides snow and ice, extremely cold temperatures can produce problems. The wind chill is determined by factoring cold temperatures and wind speed (see above Figure 3.3.8.2). For example, when the temperature is 20°F and the wind speed is 15 miles per hour, the resulting wind chill (what it really feels like) is 6°F. This type of situation can be dangerous to people outdoors because their bodies can experience rapid heat loss, resulting in hypothermia (abnormally low body temperature). Statistical information regarding hypothermia mortality is provided later in this section.

An indirect winter hazard that affects Missourians every year is carbon monoxide poisoning. Improperly vented gas and kerosene heaters or the indoor use of charcoal briquettes creates dangerous levels of carbon monoxide. There were 212 reported fatal carbon monoxide poisoning cases in 2001–2007. Accidental carbon monoxide poisonings and deaths are more likely to occur in the colder months of the year.

Table 3.3.8a lists the severe winter weather events that have received presidential declarations. The summaries that follow it describe some of the more significant severe winter weather events occurring in Missouri in recent years. (Much of this information was taken from the National Weather Service's *Storm Data and Unusual Weather Phenomena* publication.)

Table 3.3.8a Presidential Declarations for Missouri Severe Winter Weather Since 1975

Declaration Date	Disaster No.	Incident Type	Counties Declared	Type of Assistance*
March 12, 1979	EM 3071	Ice Jam, Flooding	N/A	PA
February 6, 2002	DR 1403	Ice Storm	Adair, Audrain, Barton, Bates, Benton, Boone, Buchanan, Caldwell, Carroll, Cass, Cedar, Chariton, Clark, Clay, Clinton, Cooper, Daviess, DeKalb, Grundy, Henry, Howard, Jackson, Johnson, Knox, Lafayette, Lewis, Linn, Livingston, Macon, Marion, Monroe, Morgan, Pettis, Platte, Ralls, Randolph, Ray, Saline, Scotland, Shelby, St. Clair, Sullivan, Vernon	IA
			Bates, Carroll, Cass, Cedar, Chariton, Clay, Clinton, Henry, Howard, Jackson, Johnson, Knox, Lafayette, Lewis, Linn, Macon, Marion, Monroe, Pettis, Platte, Randolph, Ray, Saline, Shelby, St. Clair, Vernon	PA
December 29, 2006	DR 1673	Severe Winter Storms	Boone, Callaway, Camden, Cole, Greene, Iron, Marion, Miller, Reynolds, St. Francois, St. Louis, Ste. Genevieve, Washington, St. Louis City	PA

Declaration Date	Disaster No.	Incident Type	Counties Declared	Type of Assistance*
January 15, 2007	DR 1676	Severe Winter Storms and Flooding	Barry, Barton, Benton, Boone, Callaway, Camden, Cedar, Christian, Cole, Crawford, Dade, Dallas, Dent, Franklin, Gasconade, Greene, Hickory, Jasper, Laclede, Lawrence, Lincoln, Maries, McDonald, Miller, Montgomery, Newton, Osage, Phelps, Polk, Pulaski, St. Charles, St. Clair, St. Louis, Stone, Texas, Warren, Webster, Wright Counties, St. Louis City	PA
December 12, 2007	DR-3281	Severe Winter Storms	Emergency Declaration for all counties in Missouri	PA
December 27, 2007	DR-1736	Severe Winter Storms	Adair, Andrew, Atchison, Audrain, Barton, Benton, Boone, Buchanan, Caldwell, Callaway, Camden, Cedar, Clinton, Cole, Dade, Daviess, DeKalb, Gentry, Grundy, Harrison, Hickory, Holt, Jasper, Lincoln, Linn, McDonald, Mercer, Miller, Moniteau, Montgomery, Morgan, Newton, Nodaway, Osage, Pike, Putnam, St. Clair, Schuyler, Scotland, Sullivan, Warren, and Worth Counties.	PA
March 12, 2008	DR-1748	Severe Winter Storms and Flooding	Bollinger, Butler, Cape Girardeau, Carter, Christian, Douglas, Greene, Madison, Mississippi, Ozark, Reynolds, Scott, Shannon, Stoddard, Texas, Wayne, Webster, and Wright Counties	PA
January 30, 2009	DR-3303	Severe Winter Storms	Emergency Declaration for all counties in Missouri	PA
February 17, 2009	DR-1822	Severe Winter Storms	Bollinger, Butler, Cape Girardeau, Carter, Dunklin, Howell, Madison, Mississippi, New Madrid, Oregon, Ozark, Pemiscot, Reynolds, Ripley, Scott, Shannon, Stoddard, Stone, Taney and Wayne Counties	PA

Declaration Date	Disaster No.	Incident Type	Counties Declared	Type of Assistance*
March 23, 2011	DR-1961	Severe Winter Storm and Snowstorm	Adair, Andrew, Audrain, Barton, Bates, Benton, Boone, Buchanan, Caldwell, Callaway, Camden, Carroll, Cass, Cedar County, Chariton, Clark, Clinton, Cole, Cooper County, Dade, Dallas County, DeKalb, Grundy, Henry, Hickory, Howard, Johnson, Knox, Laclede, Lafayette, Lewis, Linn, Livingston, Macon, Madison, Maries, Marion, McDonald, Miller, Moniteau, Monroe, Montgomery, Morgan, Newton, Osage, Pettis, Pike, Platte, Polk County, Pulaski, Putnam County, Ralls, Randolph, Ray, Saint Clair County, Saline, Schuyler, Scotland, Shelby, Sullivan, Vernon and Worth.	PA

Source: Federal Emergency Management Agency, State Emergency Management Agency
Note:*IA denotes Individual Assistance; PA denotes Public Assistance

February 15–16, 1993: Central and southern Missouri was covered with up to 21 inches of snow. The airport at Cape Girardeau received 6 inches of snow in one hour and 20 minutes.

January 14–20, 1994: Northeast, central, and east-central Missouri experienced overnight low temperatures from below zero to –20°F. Hundreds of homes and businesses had frozen and busted water pipes. Wind chills, which ranged from -30 to -50°F, kept schools closed and accounted for 15 people being admitted to local hospitals for hypothermia and frostbite.

January 16–17, 1994: A layer of ice up to 2 inches thick formed over sections of southeast Missouri, followed by 6 to 10 inches of snow. Some areas were without power for more than 24 hours. Roofs collapsed due to the heavy weight of snow and ice.

December 6, 1994: Ice accumulations of 0.5 to 1 inch were reported across northwest, north-central, and northeast Missouri. Over 75 percent of the residents in this region were without power. Phone and cable television were also out. A few rural areas were without power for at least seven days. The city of St. Joseph was declared a disaster area by Governor Mel Carnahan because of damage totaling nearly $4 million.

January 18–19, 1995: Central Missouri received heavy snows, dumping 19.7 inches over Columbia alone and setting a new 24-hour snowfall record. Parts of I-70, I-44, and other major highways were closed due to drifting snow. Snow fell at such a fast rate that snowplows and graders became stuck. Almost 5,000 birds were killed when several large chicken and turkey barns collapsed. Thousands of people were without power and telephone service. The Jefferson City and Columbia airports were closed for a time. The University of Missouri at Columbia canceled classes for the first time in nearly 17 years. State offices in Jefferson City were also closed.

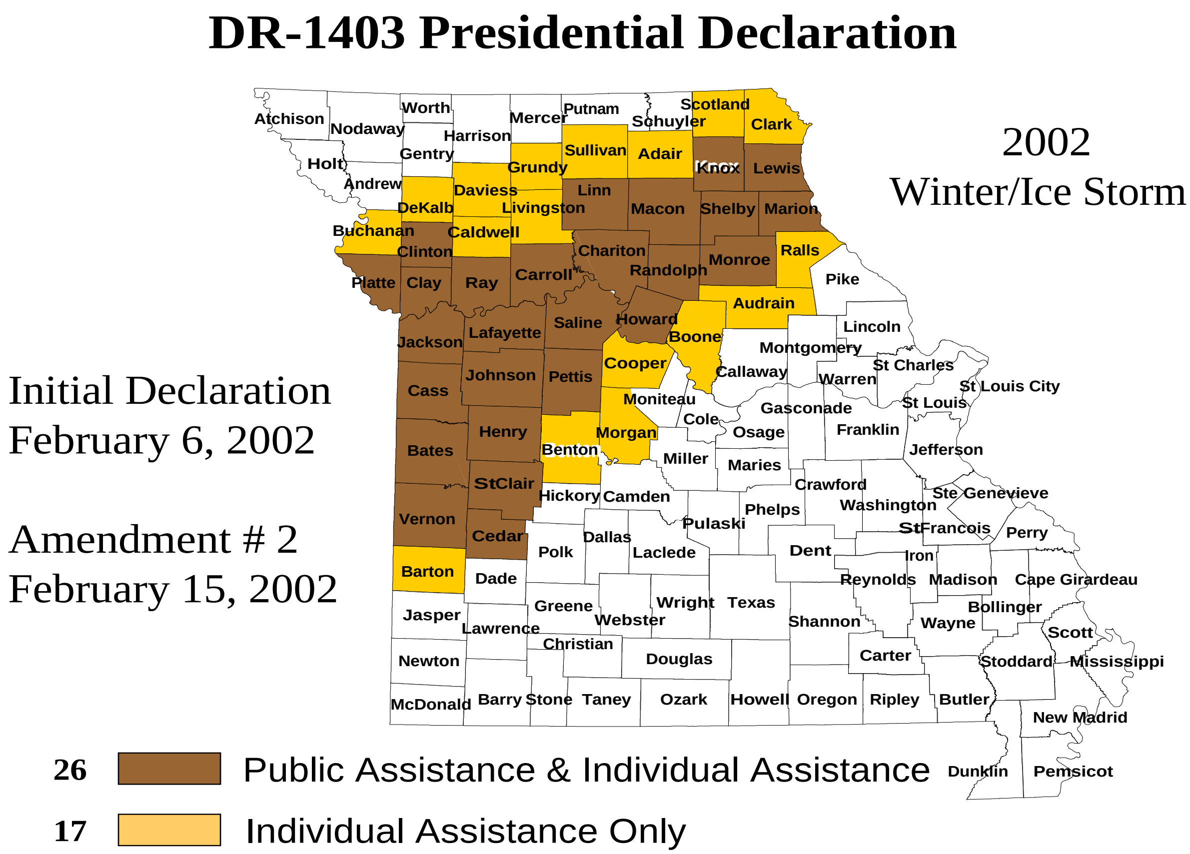
October 22–23, 1996: An early snowfall hit the Kansas City area, dumping as much as 8.5 inches of heavy wet snow. Approximately 130,000 residences were without power, and an estimated $1.5 million in property damage was reported.

January 10–13, 1997: Northwest and west-central Missouri experienced overnight low temperatures below zero. No record low temperatures were recorded, but winds gusting up to 30 miles per hour produced afternoon wind chills as low as -30 to -50°F.

April 10–11, 1997: A spring snowstorm dumped up to 24 inches in extreme north Missouri. Schuyler County alone reported $2 million in damage, mostly due to the heavy snow causing roofs on farm buildings to collapse.

January 31, 2002 (DR 1403): A massive severe winter storm system dumped snow and ice from Oklahoma to Kansas and into central and northern Missouri. In Missouri alone, more than 600,000 residents were without power, as ice-encased power lines snapped in fierce winds or were pulled down by falling trees and limbs. Loss of electricity included more than 460,000 people in the Kansas City metro area alone (Jackson, Cass, Clay, and Platte counties). Additionally, residents in a line from Kansas City to the Iowa-Illinois border were without power as rural electric cooperative lines broke as well. Outages ranged from several days to nearly two weeks. Damage to property, power restoration, and the cost of debris removal for local governments was so high that Missouri received a presidential disaster declaration (DR 1403) on February 6, 2002, which ultimately included 43 counties; 26 were designated for both Individual and Public Assistance, and 17 were eligible for Individual Assistance only (see Figure 3.3.8.3 below). The total eligible Public Assistance costs for this disaster ($61.9 million dollars as of August 2002) ranks the 2002 ice storm as Missouri's second most costly disaster to date.

Figure 3.3.8.3 - January 2002 Ice Storm



November 30–December 1, 2006 (DR 1673): A severe winter storm dropped freezing rain, sleet, ice, and snow over Missouri (see Figure 3.3.8.4 for a map of the counties that received disaster declarations). According to Pat Guinan, University of Missouri climatologist, the storm was unprecedented for the time of year it hit. Some areas of the State experienced up to 14 inches of snow. The freezing rain and sleet caused major power outages, blocked roads, and caused structural damage to buildings across the State. Eleven deaths were attributed to the event.

January 12–14, 2007 (DR 1676): A series of severe winter storms swept across Missouri causing heavy damage throughout the State. An area from Joplin to St. Louis along the I-44 corridor was the heaviest hit (see Figure 3.3.8.5 for a map of the counties that received disaster declarations). The storm system caused power outages for over 330,000 households/businesses statewide, caused 15 weather-related deaths, and sent over 4,300 citizens to more than 119 shelters. Preliminary eligible costs for Public Assistance were estimated at $109.3 million. Of this amount, approximately $51 million in damages was estimated by the 15 Missouri Electric Cooperatives that sustained damage to their electrical lines, substations and equipment.

Figure 3.3.8.4 - November–December 2006 Winter Storm

FEMA-1673-DR, Missouri
Disaster Declaration as of 12/29/2006

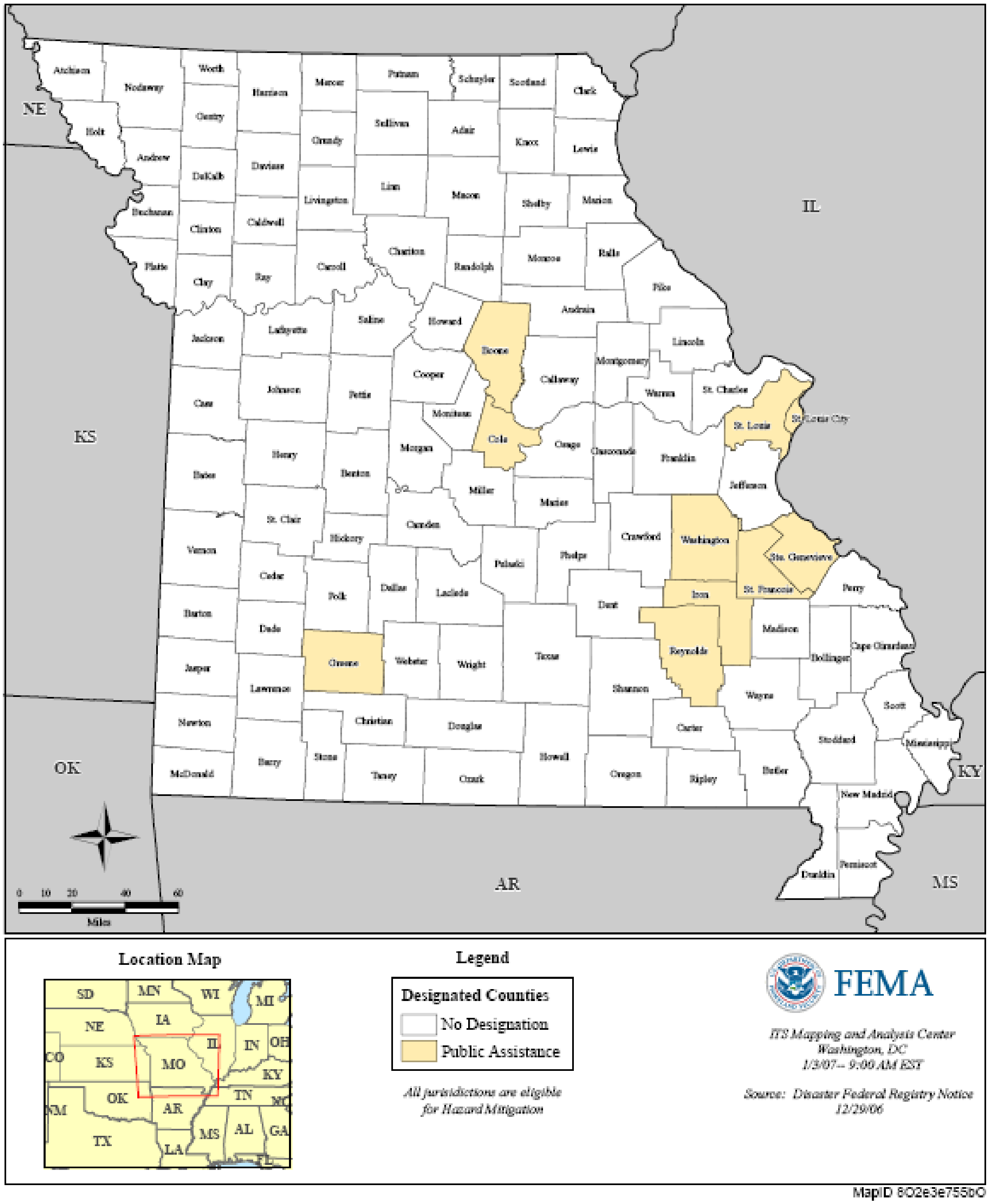
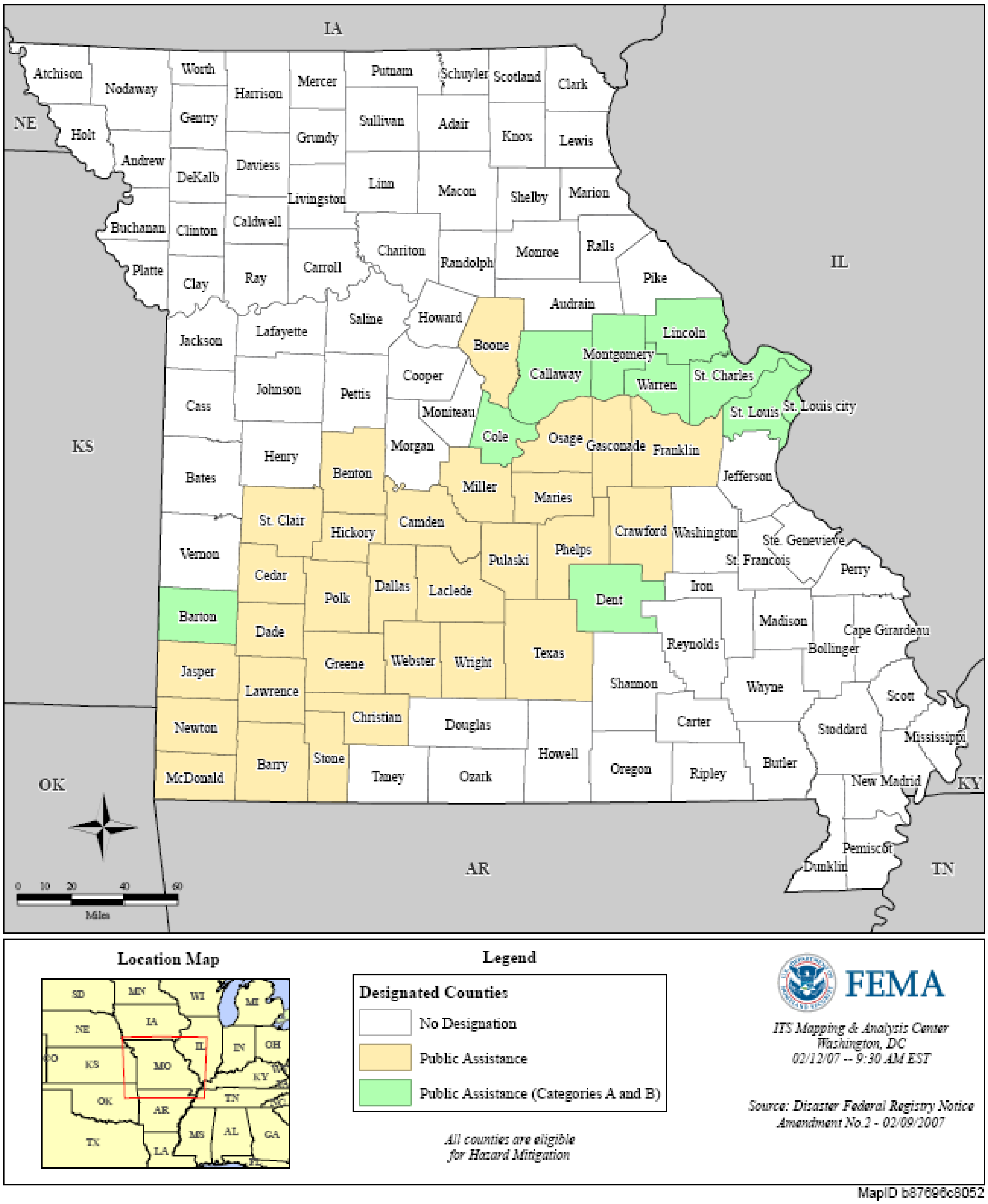


Figure 3.3.8.5 - January 2007 Winter Storms

FEMA-1676-DR, Missouri
Disaster Declaration as of 02/09/2007

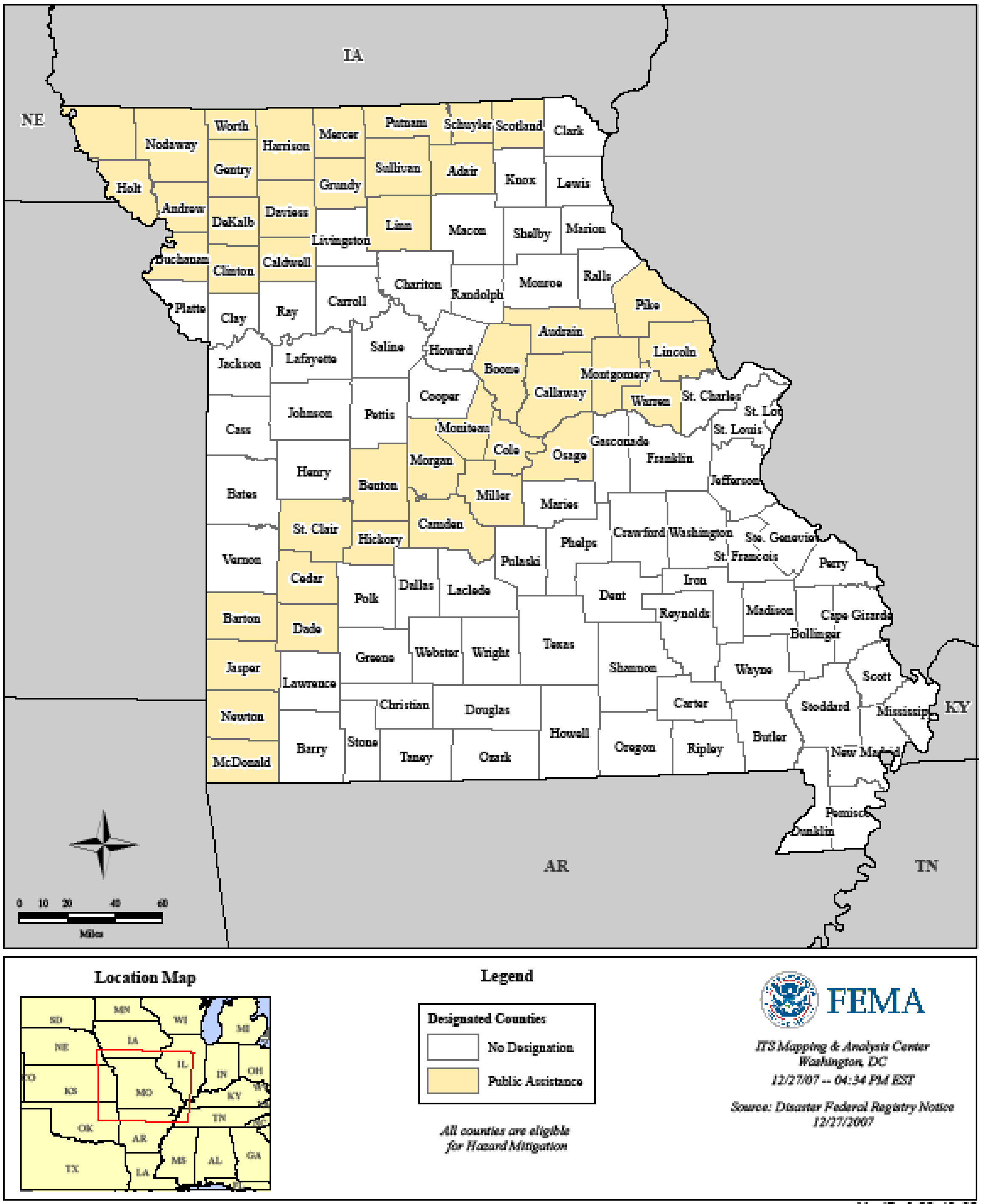


December 6, 2007 (DR-1736): A major ice storm hit parts of central, northeast, and east central Missouri (see Figure 3.3.8.6 for a map of the counties that received disaster declarations). Up to a half inch of ice accumulated along with up to one inch of sleet. Trees and power lines were down throughout the area. Many businesses had to close due to loss of electricity. Schools across the area were closed for several days. Over 32,000 power outages were reported in Boone, Callaway, Cole, Lincoln, Moniteau, and Pike Counties. Shelters were opened in Cole, Pike and Warren Counties. From 50 to 60 people stayed at the shelters in Cole County at various times with over 100 coming in daily for hot meals. There were two fatalities reported in automobile accidents across mid-Missouri.

Then another round of freezing rain was observed from December 9th through December 11, 2007. A slow moving storm system brought a long duration of freezing rain to a large portion of the nation's mid-section. Canadian high pressure kept cold air at the surface with readings in the upper 20s to lower 30s. Very warm and moist air aloft was transported north ahead of the storm system. The result of these two ingredients led to several rounds of freezing rain. Ice rapidly accumulated on many surfaces, especially trees and power lines. Ice accumulation was particularly devastating along and north of the Missouri River. Ice accumulations of 3/4 of an inch were common, with isolated accumulations around an inch, along and north of a Bean Lake to Trenton, to Unionville line. Along and south of the Interstate 70 corridor, accumulations were less than a half inch. Numerous tree branches and power lines were downed, especially along and north of a St. Joseph to Unionville. Around 165,000 residents went without power, some for almost two weeks. Twenty Missouri electric cooperatives in the Association of Missouri Electric Cooperatives sustained damage to their electrical lines, substations and equipment from the ice storm at an estimated cost of $10.8 million. There were also numerous traffic accidents due to the icy roads.

Figure 3.3.8.6 - December 2007 Winter Storm

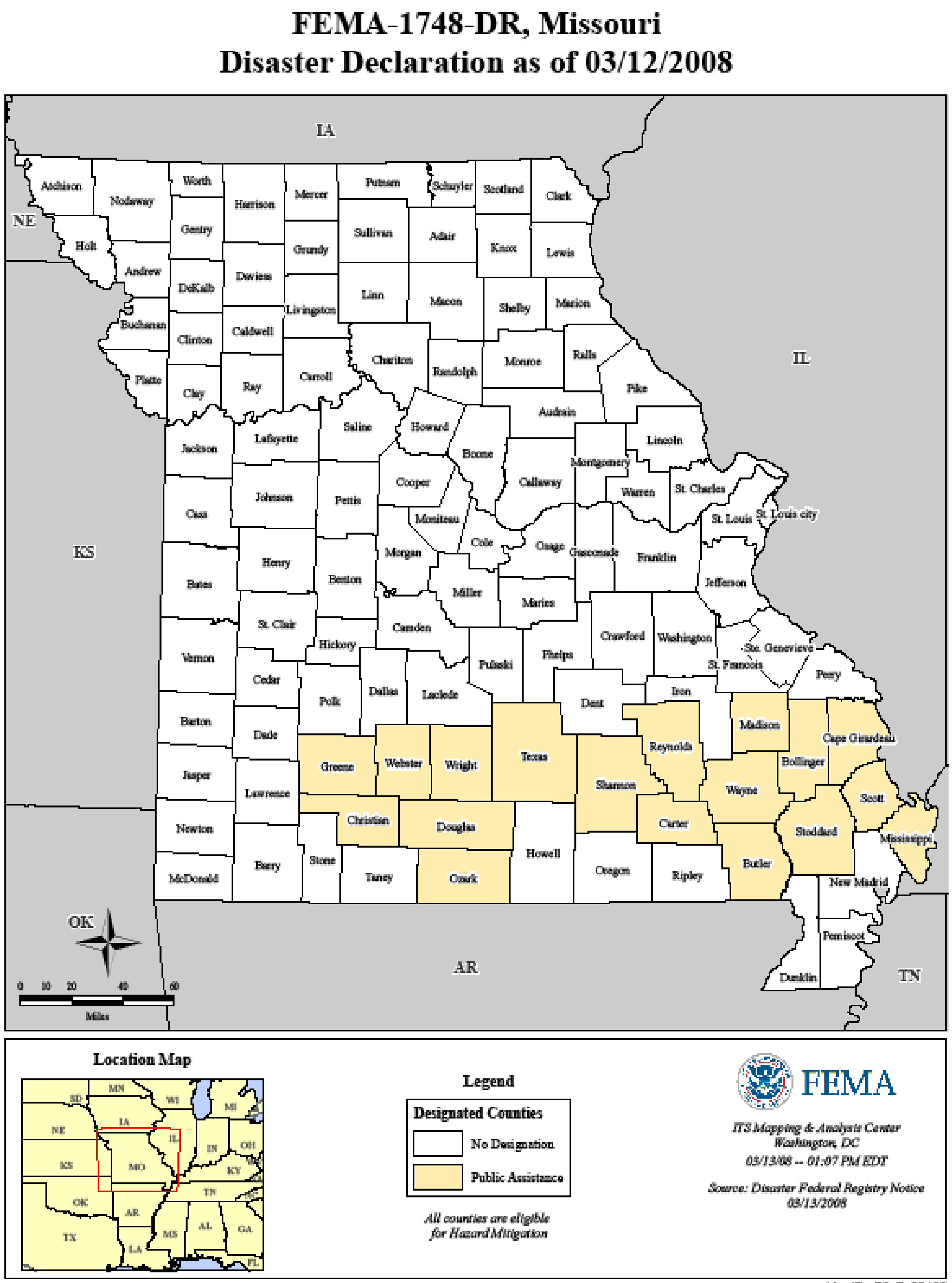
FEMA-1736-DR, Missouri
Disaster Declaration as of 12/27/2007



MapID cfe62c46a83

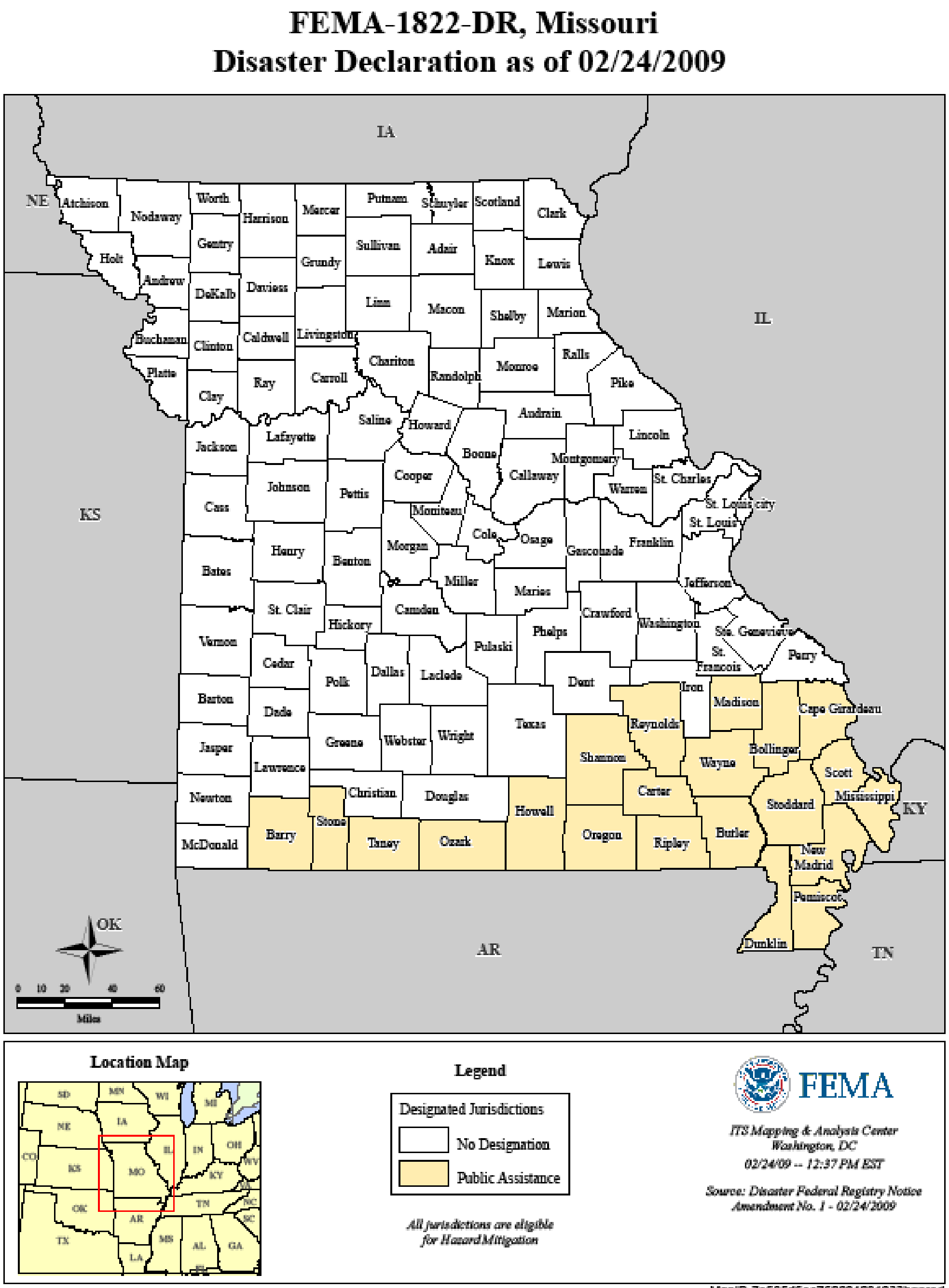
February 10-14, 2008 (DR-1748): A wintry mix of precipitation affected a large area of the southern half of Missouri (see Figure 3.3.8.7 for a map of the counties that received disaster declarations). A significant ice even occurred. Over 15,000 power outages were reported and some continued for almost two weeks. Fourteen Missouri Electric Cooperatives that belong to the Association of Missouri Electric Cooperatives sustained damage to their electrical lines, substations and equipment from the ice storm at an estimated cost of $5.1 million. Shelters and feeding stations were set up in numerous counties. There were two storm-related traffic fatalities and 54 storm-related traffic injuries.

Figure 3.3.8.7 - February 2008 Winter Storm



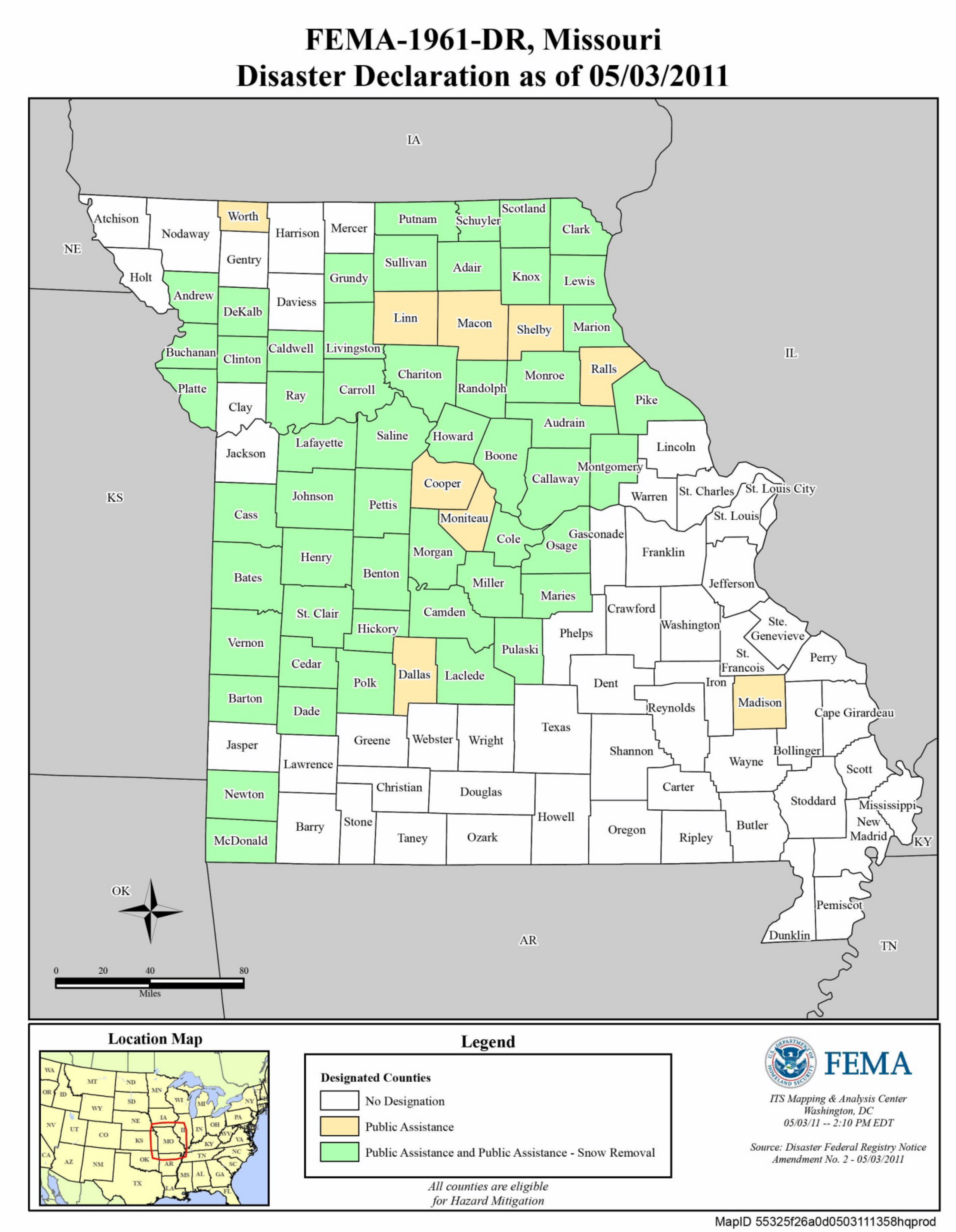
26-29, 2009 (DR-3303 and DR-1822): A cold front mixed with Gulf moisture created ice and freezing rain. High winds on February 11th caused additional damage in southern Missouri (see Figure 3.3.8.8 for a map of the counties that received disaster declarations). There were eight fatalities associated with this storm (six in traffic accidents and two with carbon monoxide poisoning). Up to 8000 customers were without power and some were out over three weeks. Seven Missouri Electric Cooperatives that are part of the Association of Missouri Electric Cooperatives sustained damage to their electrical lines, substations and equipment from the ice storm at an estimated cost of $175 million.

Figure 3.3.8.8 - January 2009 Winter Storm



January 31-February 5, 2011 (DR-1961): Across central and eastern Missouri and west-central and southwest Illinois, the storm actually came in two waves. Figure 3.3.8.9 shows those counties affected. The first wave came on Monday January 31st as several periods of sleet and freezing rain, occasionally accompanied by thunder, impacted the portions of the region. The precipitation tapered to freezing drizzle on Monday evening, as the second crippling portion of the storm began to evolve across the southern Plains. The second wave of the storm unleashed its fury on Tuesday and Tuesday night. A wintry mix of snow and sleet spread into central Missouri near daybreak Tuesday February 1st, and the wintry precipitation quickly overspread the area during the morning. This winter storm produced quite a range of hazardous winter weather conditions across the area serviced by the National Weather Service Office in St. Louis. Heavy snow fell across central and northeast Missouri into west-central Illinois with rates at times exceeding 2 inches per hour. These high snowfall rates combined with strong northwest winds gusting from 35-50 mph produced blizzard conditions with near zero visibility at times in white-outs and snow drifts of 3 to 5 feet deep. Across far northwest sections of the St. Louis metro area this warm-layer eroded with snowfall totals approaching 7-8 inches along with an inch of sleet. Through the heart of metro St. Louis, the warm-layer eroded at times and then returned, leading to constantly changing precipitation types ranging from sleet to snow to even some freezing rain. The predominant precipitation type however was sleet, and sleet accumulations of 2-4 inches were common leading to very hazardous travel conditions. The precipitation finally changed to all snow on Tuesday night with some areas seeing an additional 1-3 inches of snow accumulation. Total public assistance dollars from FEMA came to $18,956,370.86. This included grants, emergency work categories and permanent work categories.

Figure 3.3.8.9 - January 2011 Winter Storm



In addition, the Missouri Department of Transportation (MODOT) incurs costs for snow and ice removal. Table 3.3.8b shows MoDOT removal cost per lane mile compiled for fiscal years 2007-2012.

Table 3.3.8b MoDOT Snow & Ice Removal Costs from 2005-2009

Winter	Removal Cost per Lane Mile
2007-08	$725
2008-09	$580
2009-10	$711
2010-11	$547
2011-12	$206
5-Winter Average	**$553**

Source: MoDOT

According to the USDA Risk Management Agency, insured crop losses throughout the State of Missouri as a result of cold wet winter, cold winter, freeze, and frost conditions for the eleven year period of 1998 – 2008 totaled $20.9 million. A detailed listing of insured crop losses by crop, county, and, year for insured crop losses is provided at the following link: USDA Risk Management Agency Crop Claims Data.

Measure of Probability and Severity

North of Missouri River
Probability: High
Severity: Moderate

South of Missouri River
Probability: Low
Severity: Moderate
It is quite difficult to make an objective and quantitative measure of the probability and severity of snowstorms, ice storms, and extreme cold. Therefore, any analysis should be considered subjective and qualitative.

For areas north of the Missouri River, the probability of a snowstorm, ice storm, or extreme cold should be considered high due to historically higher average snowfall and lower average temperatures. However, the severity is rated moderate due to the overall level of preparedness in this area. For example, homes and businesses may be better insulated due to the higher probability of severe cold relative to other areas. Also, people living in this area may be more likely to use snow tires or purchase four-wheel-drive vehicles. People living in this area may be more likely to maintain adequate supplies of home heating fuels and consider other preparedness measures. Local and state governments may have access to more snow clearing equipment and maintain adequate supplies of materials needed for snow or ice removal. School districts and businesses may be more likely to develop and use snow routes or establish closing procedures.

Areas south of the Missouri River have a low probability of a snowstorm, ice storm, or extreme cold due to their lower average snowfalls and temperatures. Events in these areas also have a moderate potential severity. This may be due to a lower level of preparedness. People living in this area may have homes

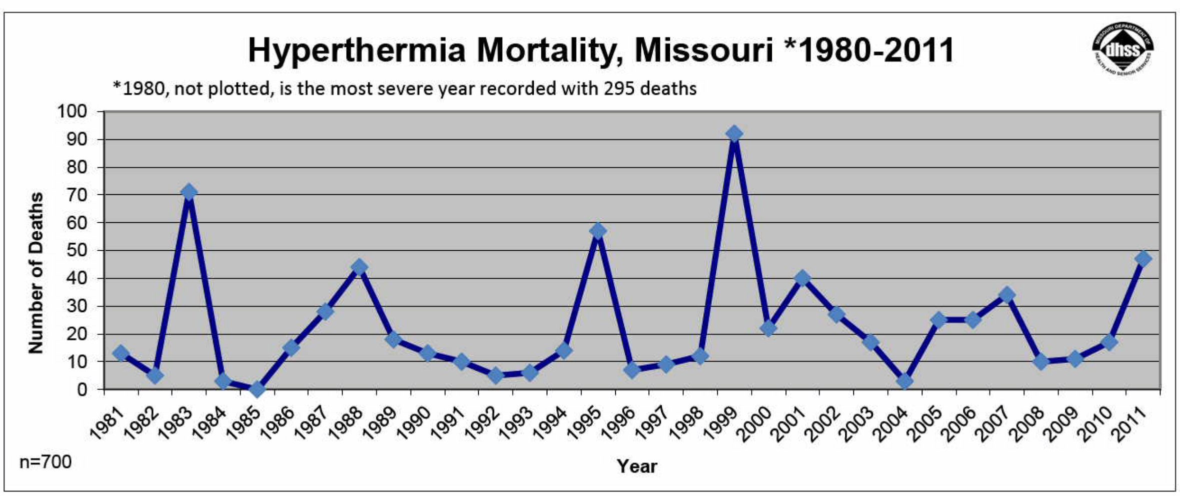
with inadequate insulation or fail to maintain an adequate supply of home heating fuels. People may be less likely to equip their vehicles with snow tires or purchase four-wheel-drive vehicles. Local and state governments may not maintain sufficient amounts of equipment and materials. Schools and businesses may not have formal snow routes or closing procedures.

Impact of the Hazard

People are adversely affected by winter storms, ice storms, and extreme cold, some more than others. Observations by the National Oceanic and Atmospheric Administration (NOAA) indicate that of winter deaths related to exposure to cold, 50 percent were over 60 years old, over 75 percent were male, and about 20 percent occurred in the home. Of winter deaths related to ice and snow, about 70 percent occur in automobiles, and 25 percent are people caught in storms. Winter storms are considered deceptive killers because most deaths are indirectly related to the storm. These indirect deaths include people who die in traffic accidents on icy roads and people who die of hypothermia from prolonged exposure to cold. In addition, overexertion can be a related hazard to winter storms. Shoveling heavy snow, pushing a car, or walking in deep snow are all hard labor tasks, which combined with the strain from the cold can result in a heart attack. Sweating extensively can lead to a chill and hypothermia. As noted earlier, ice storms can result in significant economic costs to homeowners, business owners, and utility companies. The ice storm in December 1994 demonstrated the environmental damage that can occur. Thousands of trees and plants were cut down or damaged as a result of the ice storm. The problem of debris clearance caused environmental impacts due to the permitted burning of debris and reduced landfill space.

Hypothermia: Hypothermia is defined as a cold injury associated with a fall of body temperature to less than 94.1ºF, which results from unintentional exposure to a cold environment. Data from the Missouri Department of Health and Senior Services shows that, in Missouri, 454 people have died from the cold during the winter months between 1979 and 2007 (data collection of hypothermia first began in Missouri in 1979).

Figure 3.3.8.10 - Hypothermia Deaths, Missouri: Winter Seasons 1980–2011

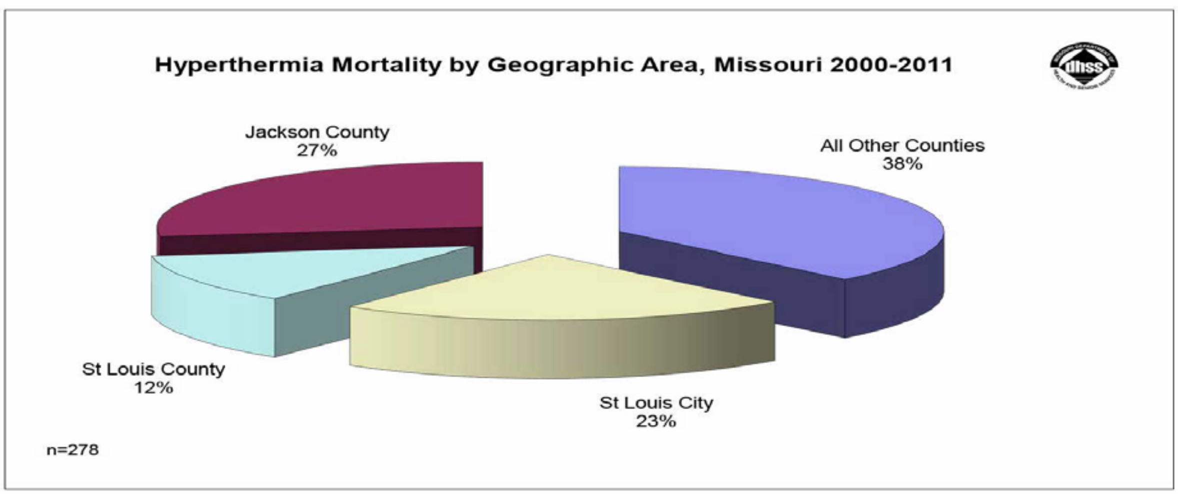


Source: Missouri Department of Health and Senior Service, http://health.mo.gov/living/healthcondiseases/hyperthermia/pdf/hyper1.pdf

The elderly are more likely to be victims of cold-related illness resulting in death. Too often, handicapped or elderly individuals fall outside their homes and are unable to reach shelter or help. During the cold weather seasons 2000 - 2011, 141 (50.7 percent) hypothermia deaths were of people aged 65 years and older. Deaths of individuals between the ages of 25 and 64 often have a contributing cause of substance abuse or a debilitating medical condition. Since 2000, there have been 123 (44.2 percent) hypothermia deaths in this population. Fortunately, deaths in people age <25 years are rare, accounting for only 14 (5.0 percent) of the total 278 Missouri hypothermia deaths during this time frame. Twelve of the deaths were children less than age 5 years. From cold weather winter seasons 2000 through 2011, the largest number of deaths were among white males, making up 49.0 percent (136) of the 278 total cold-related deaths.

In Missouri, slightly more deaths have occurred in the more rural areas of the State than in the metropolitan areas. Jackson County had 75 (27 percent) deaths, St. Louis County had 33 (12 percent), and St. Louis City had 63 (23 percent) of the total 278 hypothermia deaths since 2000.

Figure 3.3.8.11 - Hypothermia Deaths by Geographic Area, Missouri: 2000–2011*



Source: Missouri Department of Health and Senior Services, http://health.mo.gov/living/healthcondiseases/hyperthermia/pdf/hyper2.pdfThe information below is from the Impact Analysis of Potential for Detrimental Impacts of Hazards done for the Emergency Management Accreditation Program.

Table 3.3.8c EMAP Impact Analysis: Severe Winter Weather

Subject	Detrimental Impacts
Health and Safety of Persons in the Area at Time of Incident	Localized impact expected to be severe for affected areas and moderate to light for other less affected areas.
Health and Safety of Personnel Responding to the Incident	Adverse impact expected to be severe for unprotected personnel and moderate to light for trained, equipped, and protected personnel.
Continuity of Operations	Unlikely to necessitate execution of the Continuity of Operations Plan.
Property, Facilities, and Infrastructure	Localized impact to facilities and infrastructure in the areas of the incident. Power lines and roads most adversely affected.

Subject	Detrimental Impacts
Delivery of Services	Localized disruption of roads and/or utilities caused by incident may postpone delivery of some services.
The Environment	Environmental damage to trees, bushes, etc.
Economic and Financial Condition	Local economy and finances may be adversely affected, depending on damage.
Regulatory and Contractual Obligations	Regulatory waivers may be needed locally. Fulfillment of some contracts may be difficult. Impact may temporarily reduce deliveries.
Reputation of or Confidence in the Entity	Ability to respond and recover may be questioned and challenged if planning, response, and recovery not timely and effective.

Synopsis

As noted in this report, snowstorms, ice storms, and extreme cold can interact to cause many hazards. Only a few degrees may be the difference between rain, ice, or snow. Duration and intensity of any of these events will determine the overall impact of a particular event. Wind speed may be the difference between a minor snow and a blizzard. These events cannot be prevented. Preparedness for these events may be the greatest single factor to reduce loss of life, injury, and property damage. NOAA weather broadcasts via radio and television provide important information for people to prepare and thus reduce risks to their lives and property.

For additional information on vulnerability to severe winter weather, see Section 3.5.8.

3.3.9 Drought

Description of Hazard

Droughts are regional climatic events which can impact large areas ranging from several counties in Missouri to the entire Midwestern region. Areas with extensive agricultural land use can experience particularly significant impacts. Drought is not a hazard that affects just farmers, but can impact the nation's entire economy. Its outcome can adversely affect a small town's water supply, homeowners, small business owners, commodity markets, and tourism. Figure 3.3.9.1 depicts the affects drought has on soil.

Figure 3.3.9.1 - Dry Earth Resulting from Drought

Source: Image by Thomas Castelazo, GFDL

The National Weather Service defines drought as "a deficiency in precipitation over an extended period, usually a season or more, resulting in a water shortage causing adverse impacts on vegetation, animals, and/or people." The Missouri Drought Plan distinguishes between the following five categories of drought (MDNR, 2002):

- **Agricultural Drought**—Defined by soil moisture deficiencies

- **Hydrological Drought**—Defined by declining surface and groundwater supplies
- **Meteorological Drought**—Defined by precipitation deficiencies
- **Hydrological Drought and Land Use**—Defined as a meteorological drought in one area that has hydrological impacts in another area
- **Socioeconomic Drought**—Defined as drought that impacts supply and demand of some economic commodity

The purpose of the plan is to guide the state's actions during a drought crisis in order to address the needs of citizens and recover as quickly as possible (MDNR, 2002). Each of these categories relates the occurrence of drought due to water shortfall in some component of the hydrological cycle. Each type of drought occurs naturally, and affects patterns of water and land use. In urban areas, drought can affect those communities that depend on reservoirs for water, and decreased water levels due to insufficient rain can lead to restricted water use. In agricultural areas, drought during the planting and growing season can have a significant impact on yield (Hays, 1995).

The National Weather Service definition of an agricultural drought connects the specific parameters that define hydrological drought, such as dryness or precipitation shortfalls with actual impacts on agriculture. According to the NCDC, drought is "a deficiency in precipitation over an extended period, usually a season or more, resulting in a water shortage causing adverse impacts on vegetation, animals, and/or people," (NCDC, 2006). The government of India specifically defines agricultural drought as "a combination of temperature and precipitation over a period of several months leading to a substantial reduction in yield (bushels per acre) of one or more of the three major food grains (wheat, soybean, corn). A substantial reduction is defined as a yield (bushels per acre) less than 90 percent of the yield expected with temperature/precipitation equal to long term average values," (NRCS, 2012).

Regardless of the specific definition, droughts are difficult to predict or forecast, both as to when they will occur and how long they will last. According to Dr. Grant Darkow, Department of Atmospheric Science, University of Missouri–Columbia, there is a recognizable flow in the atmosphere from west to east, and "if the upper-flow pattern remains unchanged for an extended period of time, the surface-flow patterns also tend to persist in time and place for longer than normal, producing extended wet, dry, hot or cold spells," (Darkow, 2013). When the upper air-flow pattern is typified by air flowing in a broad arc over the central plains with higher speeds in southern Canada than over the United States, then the air over the southern plains will be "characterized by a weak clockwise circulation." (Darkow, 2013) Storm systems coming off the Pacific Ocean will cross the extreme northwestern states and southern Canada, thus bypassing the Midwestern states. When this flow pattern persists, the result can be a prolonged period of drought (Darkow, 2013).

The Missouri Drought Plan lays out a phased response system to warn the public about drought conditions and guide the level of response necessary for addressing the drought conditions (MDNR, 2002).

Missouri's Drought Response System is divided into four phases:

- **Phase I: Advisory Phase**—Requires a drought monitoring and assessment system to provide enough lead time for state and local planners to take appropriate action
- **Phase II: Drought Alert**—When the PDSI reads -1.0 to -2.0, and stream flows, reservoir levels, and groundwater levels are below normal over a several month period, or when the Drought

Assessment Committee (DAC) determines that Phase II conditions exist based on other drought determination methods

- **Phase III: Conservation Phase**—When the PDSI reads -2.0 to -4.0, and stream flows, reservoir levels, and groundwater levels continue to decline, along with forecasts indicating an extended period of below-normal precipitation, or when the DAC determines that Phase III conditions exist based on other drought determination models
- **Phase IV: Drought Emergency**—When the PDSI is lower than -4.0, or when the DAC determines that Phase IV conditions exist based on other drought determination methods (Hays, 1995)

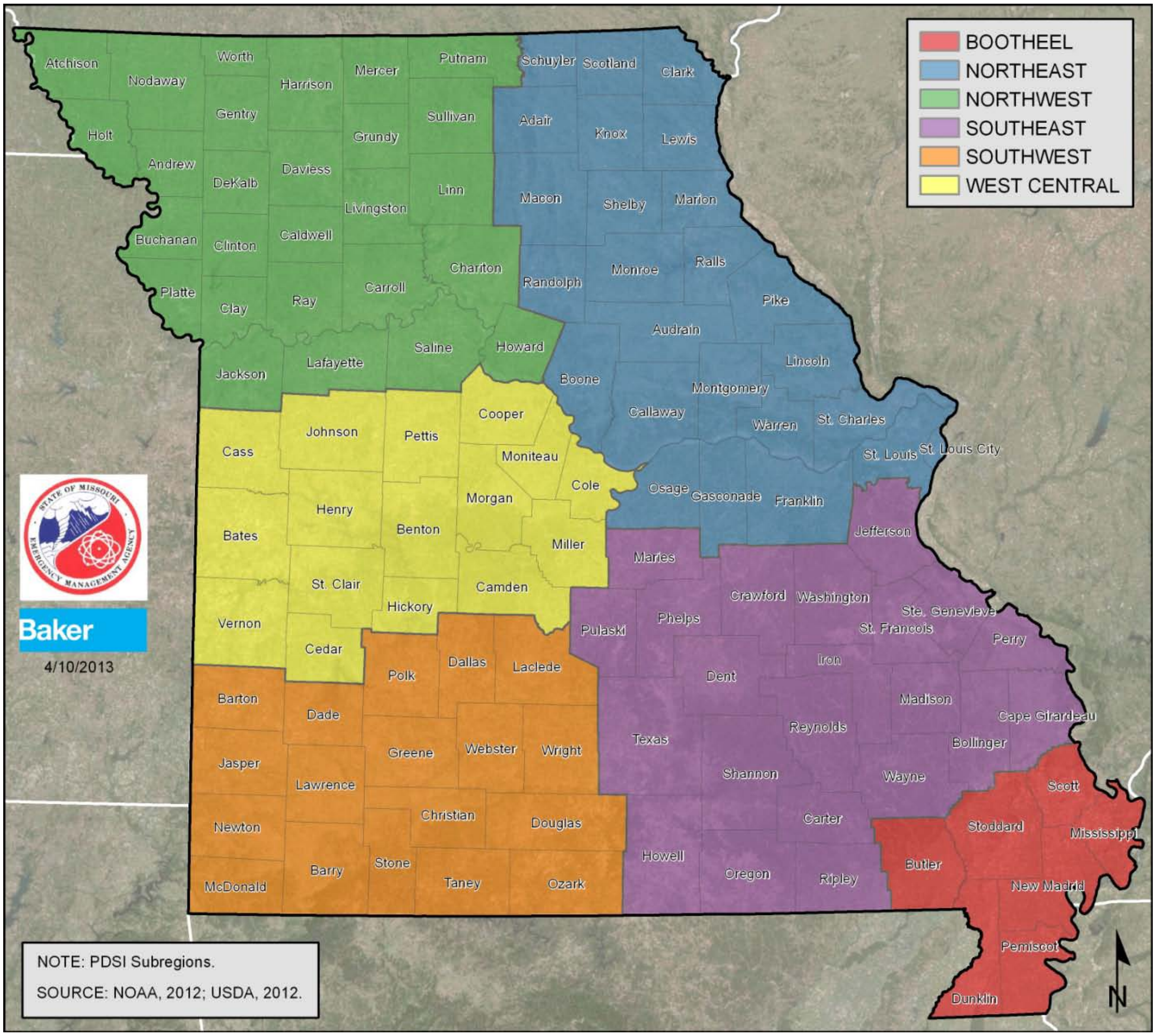
The most commonly used indicator of drought and drought severity is the Palmer Drought Severity Index (PDSI), which is published jointly by the National Oceanic and Atmospheric Administration (NOAA) and the U.S. Department of Agriculture (USDA) (see Table 3.3.9a). The PDSI measures the difference between water supply (in terms of precipitation and stored soil moisture) and demand (the amount of water required to recharge soil and keep rivers, lakes, and reservoirs at normal levels). The result is a scale from +4 to -4, at 1.0 and 0.5 intervals. By relating the PDSI to a regional index, one can compile data that reflects long-term wet or dry tendencies. Once PDSI levels drop below -1.0, the phased Missouri Drought Response System is enacted, as described in the Missouri Drought Plan and listed above (MDNR, 2002).

Table 3.3.9a - Palmer Drought Severity Index (U.S. Drought Portal, 2013)

PDSI Value	Severity Category	Missouri Drought Response System Phase
4.0 or more	Extreme wet	*none*
3.0 to 3.99	Very wet	*none*
2.0 to 2.99	Moderately wet	*none*
1.0 to 1.99	slightly wet	*none*
0.5 to 0.99	Incipient wet spell	*none*
0.49 to -0.49	Near normal	*none*
-0.5 to -0.99	Incipient dry spell	*none*
-1.0 to -1.99	Mild drought	Phase II: Drought Alert
-2.0 to -2.99	Moderate drought	Phase III: Conservation Phase
-3.0 to -3.99	Severe drought	Phase III: Conservation Phase
-4.0 or less	Extreme drought	Phase IV: Drought Emergency
Phase I: Advisory Phase*, does not have an associated PSDI Value. This response Phase is implemented by the MDCNR and the Climate Weather Committee (CWC) as deemed necessary.*		

For PDSI reporting purposes, Missouri is divided into six regions of similar climatic conditions: Northwest, Northeast, West Central, Southwest, Southeast, and Bootheel (MO DNR, 1997). These regions are illustrated in Figure 3.3.9.2.

Figure 3.3.9.2 - Palmer Drought Severity Index: Missouri Sub-regions



In addition to the NOAA/USDA indices, water management agencies in Missouri have access to the Missouri Crop Progress and Condition Report, produced by the National Agricultural Statistics Service. These reports provide detailed statistical information on weather conditions, crop conditions, topsoil moisture supply, and subsoil moisture supply by sub-region throughout Missouri (NASS, 2013).

Other indicators of drought include high water demand versus available supplies, reduced stream flows, declining reservoir levels, precipitation deficits, falling water levels in wells, and low soil moisture.

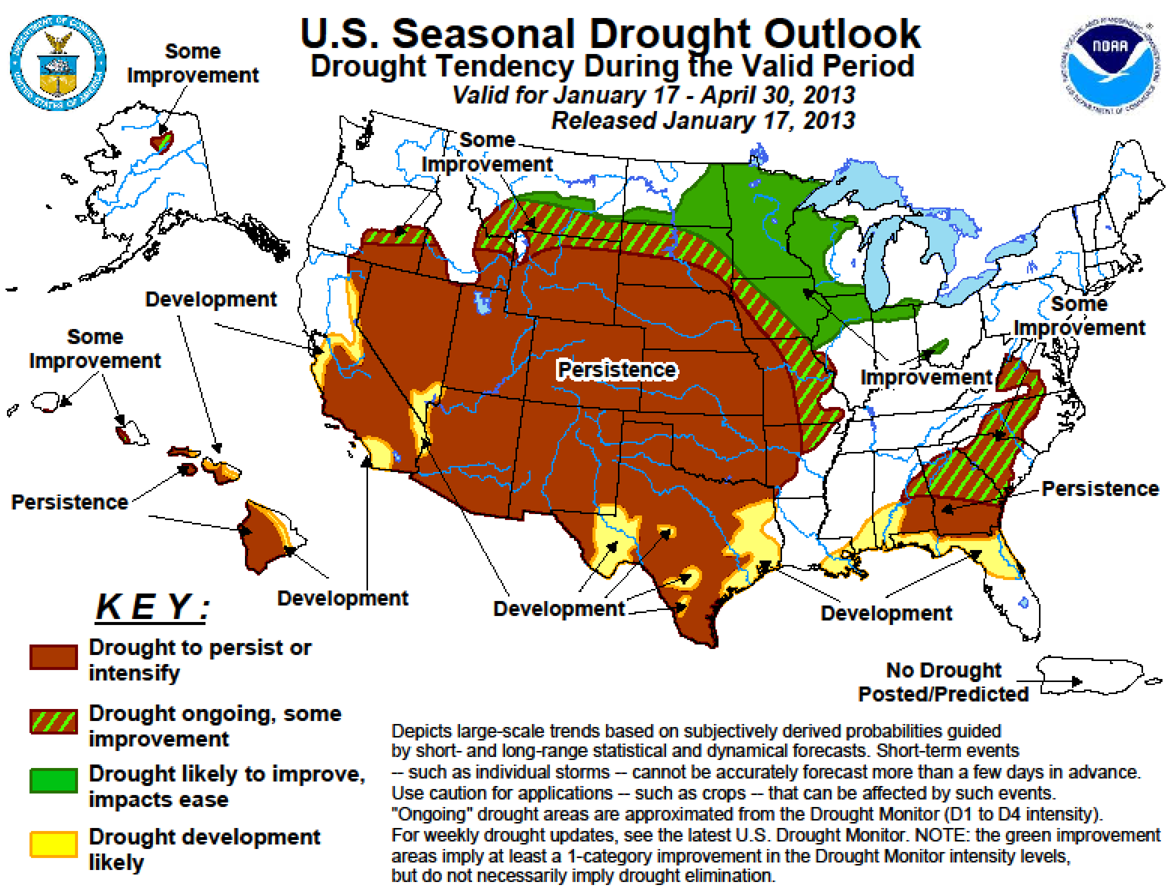
The difficulty with recognizing or predicting drought is that no single indicator can be reliably used to predict onset. Regional indicators such as the PDSI are limited in that they respond slowly to deteriorating conditions, whereas observations of surface conditions and groundwater measurements or rainfall may only provide a "snapshot" of a very small area.

Consequently, the use of a variety of drought indicators is essential for effective assessment of drought conditions, and the PDSI is the primary means to assess drought severity.

Historical Statistics

Currently, Missouri is facing its worst drought in 30 years with all 114 counties declared primary natural disaster areas, as of July 17, 2012. (NRCS 2013). More detailed information about the drought is available in the Table 3.3.9b: Missouri Drought Past Occurrences. The National Weather Service Climate Prediction Center expects the existing drought to persist throughout most of Missouri and much of the Midwestern and Western regions as show in Figure 3.3.9.3 below.

Figure 3.3.9.3 - U.S. Seasonal Drought Outlook (NOAA, 2013)



According to the Missouri Climate Center, Missouri's average annual rainfall ranges from about 34 inches in the northwest to about 50 inches in the southeast. Even the driest areas of Missouri have more rainfall than most western states; however, lack of rainfall impacts certain parts of the State more than others because of alternate source availability and usage patterns (Hu, 2004).

Southern Missouri—Most of the southern portions of Missouri are less susceptible to problems caused by prolonged periods without rain because of abundant groundwater resources in the region. Even with decreased stream flows or lowered reservoir levels, groundwater is still a viable resource in southern

Missouri. Row-crop farming is not extensive; therefore agricultural needs aren't as great as in other parts of the State. The only exception is in the southwestern and southeastern areas where irrigation is used.

Northern and West Central Missouri—Most of the northern and west-central portions of Missouri are underlain by rocks that are not conducive to water-bearing formations. They yield only small amounts of water, even during periods of normal and above-normal rainfall. Under drought conditions, adequate amounts of water cannot be pumped from the rock formations of northern Missouri to supply even domestic needs. Most streams in northern Missouri do not receive appreciable groundwater recharge. During periods of drought, these streams are generally reduced to a series of pools, or may become completely dry. Streams and water impoundments are the only localized sources of water during droughts, and even these limited resources are at risk when the drought is prolonged. Agriculture in west-central and northern Missouri is usually the first to feel the effects of drought. Although row-cropping is more extensive in this part of the State, irrigation is generally not feasible except on the floodplains of major rivers.

The National Climatic Data Center (NCDC) created a map series showing the national history of drought from 1896 (top left) to 2012 (bottom right). The frequency of drought impacting Missouri is clearly displayed in the maps throughout the years in Figure 3.3.9.4 below. As mentioned earlier, the difficulty with recognizing or predicting drought is that no single indicator can be reliably used to predict onset of drought. Also, historical information specific to MO is limited in availability.

Figure 3.3.9.4 - Drought's Foot Print by NCDC, NOAA (Park, 2012)

Historical drought information for Missouri is difficult to find. However, a list of significant weather events in Missouri from the Missouri Climate Center during the twentieth century highlights droughts in 1901 (the second driest year on record with 25.86 inches of precipitation), the dustbowl years of the 1930s and 40s, the 1950s (this was drier than the dustbowl years), and 1988. According to the Missouri State Climatologist, the worst drought on record for southwestern Missouri occurred over a five year period between 1952 and 1956. With just 25.35 inches of precipitation, 1953 is Missouri's driest year on record. There is limited data available on droughts since the 1950s. Table 3.3.9b below provides detailed

drought information from MO DNR since 1999. (MU, 2013). Last year, 2012, was the driest year in southwestern Missouri since 1980. Additionally, tree-ring research from scientists at the University of Missouri suggests that Missouri suffered a severe drought from 1948 to 1958. The tree-ring patterns also show that Midwest droughts have occurred on a regular 18.6-year cycle (Jenkins, 2006).

Table 3.3.9b Missouri Drought Past Occurrence

DATE	DESCRIPTION
July 1999 to November 1999	In September 1999, a Phase I Drought Advisory was declared for the state of Missouri. Governor Carnahan declared an agricultural emergency for the entire state. Agricultural reporting showed a 50 percent crop loss from the drought in 50 counties, with severe damage to pastures for livestock, corn crops, and Missouri's top cash crop—soybeans. On October 13, 1999, Dan Glickman, USDA secretary declared all Missouri counties agricultural disaster areas, making low-interest loans available to farmers in Missouri and contiguous states. The drought intensity increased through autumn and peaked at the end of November 1999. In fact, the five-month span between July and November became the second driest July-November period in Missouri since 1895, averaging only 9.38 inches of rain.
March 2000 to May 2000	A wetter-than-normal winter diminished dry conditions in central and southern Missouri, but long-term moisture deficits continued to exist. At the same time, the remainder of the State (roughly north of the Missouri River) continued under drought conditions. Overall dry conditions returned through much of the State in March 2000, and costly wildfires and brush fires (70) erupted in many counties. By May, the entire state was under a Phase II Drought Alert level, and on May 23, Governor Carnahan announced activation of the Missouri Drought Assessment Committee (DAC), made up of state and federal agencies and chaired by Jeff Staake the DNR deputy director.
May 2000 to July 2000	At a May 25, 2000, meeting, the DAC selected a subcommittee (guided by the Missouri Drought Plan) to determine the drought status of each county. In June, based on observations across the State and projections of future rainfall, the committee upgraded the drought status for 27 northern Missouri counties to Phase III Conservation. This was based on concerns for water supplies and agricultural impacts. The City of Milan in Sullivan County was among the most severely affected in terms of water supplies. In June, a total of 80 Missouri counties remained under the Phase II Alert level, while 7 counties in southeast Missouri (Butler, Dunklin, Mississippi, New Madrid, Pemiscot, Scott, and Stoddard) remained under Phase I Advisory conditions. By mid-July 2000, some areas of northern Missouri benefited from additional rainfall, while drier conditions prevailed in other areas. At its July 12 meeting, the DAC revised its assessment, placing 30 counties under Phase III Conservation conditions, including 10 counties in the south-central area. The remaining 84 counties in the State were under Phase II Drought Alert conditions. This included seven counties in northern Missouri, which were downgraded from Phase III Conservation, and seven counties in Southeast Missouri, which were previously assessed as Phase I Advisory. To ease the agricultural impact of the drought during the summer months, Governor Carnahan gained release of over one million acres from the Conservation Reserve Program (CRP) to provide farmers and ranchers in 21 counties additional sources to cut hay for livestock feed. Also, livestock producers in 16 counties were released from CRP contracts to allow cattle grazing on certain idle lands.

DATE	DESCRIPTION
2002 to June 2004	The drought of 2002 caused tremendous financial hardships to many Missouri crop and livestock producers. The financial impact of the drought on producers in turn impacted the local communities and the State in terms of reduced economic activity. This drought cost an estimated $46 million in 2002 and $575 million for 2003 in terms of Missouri's agricultural and economic productivity. Drought conditions encompassed most of the northwestern quarter of Missouri. Severe drought conditions affected the northwest, west-central, and some portions of southwest Missouri, causing water conservation measures to be taken and restrictions to be imposed. For some areas, this was the second driest year since 1914. The only drier year was in 1988. 2002 had the driest November–December period on record for northwestern and north-central Missouri. The drought continued through 2003 and 2004 with conditions improving in 2004. As of March 3, 2004, drought conditions still encompassed most of the northwestern quarter of Missouri with 18 counties designated as being in Phase III Conservation. The drought conditions improved due to an increase in precipitation between March and June 2004. In June 2004, Missouri was considered drought-free for the first time in three years.
July 2005 to September 2005	The drought of 2005, as in the previous drought of 2003-2004, caused tremendous hardships to many Missouri crop and livestock producers. According to the University of Missouri's Food and Agriculture Institute, the estimated losses to the corn and hay crops alone will likely top $370 million. For some Missouri farmers, this will be a drier year than 1988. By late July, the drought conditions encompassed all but nine counties in the northwestern corner of the State. Severe drought conditions affected counties in the southwest through the northeast part of the State. Effective August 23, 2005, due to the secretarial disaster designation, 114 Missouri counties and St. Louis City were designated as natural disasters for physical and/or production-loss loan assistance from Farm Service Agency (FSA). The drought conditions began to improve by late August and into September.
September 2006 to December 2006	The drought of 2006 has had a tremendous agricultural impact on Missouri farmers. As of September 2006, FSA reported that 26 counties had requested Emergency Conservation Program (ECP) funds with two additional counties pending. The livestock industry is feeling severe effects from the current drought. Hay supplies are short, and water supplies for livestock continue to decline. USDA reported that the new $50 million program for livestock producers, called the Livestock Assistance Grant Program, will provide this money in Section 32 to states in block grant form. The drought has also had an impact on local water supplies with several communities issuing mandatory conservation measures. On September 19, 2006, only 10 counties in the southeastern portion of the State were free of drought. By November 28, 2006, 5 more counties were drought-free and 11 more had entered Phase III for a total of 49 counties in the Conservation Phase. In October 2006, the USDA designated 85 Missouri counties as a primary natural disaster area (and extended assistance eligibility to 20 contiguous counties) due to losses caused by the drought beginning January 1, 2006. Only the southeast corner and the extreme northwest corner were not eligible for assistance. According to Pat Guinan, University of Missouri climatologist, a snowstorm in late November/early December put a dent in the drought, but more rain and snow are needed for conditions to return to normal.
February 2007 to October 2007	No serious drought conditions have been reported since 2006. The Interim Drought Status map (February 13, 2007) indicates that there were 76 counties in Phase I—Advisory Phase, and 38 counties with no drought. The U.S. Drought Monitor map (July 31, 2007) indicates that several counties north of I-70 and all counties along the Mississippi River to the south had abnormally dry conditions. The Palmer Drought Severity Index map for October 16, 2007, forecasts moderate to extreme drought for most of the counties in Missouri. On October 23, 2007 (see Figure 3.22) shows that there were 61 counties with no drought, 33 counties in Phase I—Advisory Phase, and 20 counties Phase II—Drought Alert.

DATE	DESCRIPTION
June 2010 to March 2011	Starting in July 2010, precipitation levels dropped as temperatures remained high, stressing crops in southeast Missouri. Rainfall in late July and August and Tropical Storm Hermine in September gave little relief as water shortage continued. Continued lack of rainfall led to severe (D2) drought conditions in September and extreme (D3) conditions in October the Bootheel region of Missouri. The drought expanded north and west during October and wildfire risk increased due to the dry conditions. Several wildfires occurred in November in Wayne and Carter counties. Precipitation in February provided some relief from the drought and reduced conditions back to severe, then additional rainfall in March further improved the drought status in Missouri.
July 2011 to November 2011	The south west region of Missouri experienced severe (D2) drought at the end of July 2011. Crops were hard hit, and many failures were reported. Crop damages up to $10 million were recorded along with reports of impacts to livestock and their feed. Rainfall in November was double the normal amount for the month and helped to reduce the level of drought to moderate (D1) or abnormally dry (D0).
May 2012 to January 2013 and beyond	May of 2012 brought below average rainfall and resulted in crop damage, low soil moisture levels, and reduced stream flows. By the end of the month, the southern and Bootheel regions of Missouri reached a severe (D2) level drought. In June the drought worsened, meriting an upgrade to an extreme (D3) drought. Fire warnings were high, soybean, corn, and sorghum crops became stressed, and soils moisture levels continued to drop. The drought expanded further into the Ozarks, East Central, Northeast, and Southeast Missouri by the end of June. During July, the drought level was heightened to exceptional (D4) conditions. Crops continued to decline and more livestock had to switch to hay bales for feed. Fourth of July fireworks were canceled due to the dangerously dry conditions. The drought continued for the remainder of 2012 and into 2013. The majority of the state has remained at a severe (D2) drought condition as of January 2013. All counties in Missouri have been declared disaster areas due to the drought.

Table 3.3.9c provides a summary of PDSI values for the six climate sub-regions throughout Missouri for severe or extreme drought events experienced between December 1895 and November 2012. It's clear that periods of dry soil moisture conditions vary by region; however, several widespread (i.e. low PDSI values for multiple climate divisions) events have occurred. For example, between 1952 and 1956, all divisions reported extremely low PDSI values. This includes the Northeast Climate Division 2 which reported a PDSI value of -7.74 in March 1954.

Table 3.3.9c Summary of PDSI Values by Sub-region (NCDC 2012)

NORTHWEST CLIMATE DIVISION 1			NORTHEAST CLIMATE DIVISION 2		
Drought Periods	**Duration**	**Lowest PDSI**	**Drought Periods**	**Duration**	**Lowest PDSI**
5/1897 - 12/1897	8 months	-3.15 in 12/1897	10/1900 - 5/1902	20 months	-5.28 in 2/1902
5/1901 - 4/1902	12 months	-4.97 in 4/1902	4/1913 - 4/1915	25 months	-4.53in 7/1914
7/1916 - 8/1918	26 months	-3.60 in 3/1918	2/1930 - 4/1931	15 months	-4.50 in 2/1931
2/1932 - 8/1934	31 months	-7.18 in 8/1934	6/1933 - 8/1934	15 months	-6.77 in 7/1934
3/1936 - 8/1941	66 months	-4.94 in 8/1941	8/1935 - 8/1936	13 months	-5.68 in 8/1936
5/1953 - 9/1957	53 months	-6.33 in 2/1957	9/1939 - 8/1941	24 months	-3.30 in 8/1941
3/1962 - 3/1964	25 months	-4.23 in 2/1964	5/1952 - 1/1957	57 months	-7.74 in 3/1954
5/1975 - 7/1977	27 months	-3.94 in 4/1977	4/1962 - 12/1964	33 months	-4.87 in 2/1964
4/1980 - 4/1981	13 months	-3.26 in 4/1981	5/1975 - 7/1977	27 months	-3.14 in 7/1977
1/1988 - 6/1989	18 months	-4.82 in 4/1989	5/1979 - 3/1981	23 months	-4.20 in 3/1981

Table 3.3.9c Summary of PDSI Values by Sub-region (NCDC 2012)					
7/1999 - 5/2000	11 months	-3.41 in 5/2000	4/1988 - 1-1990	22 months	-3.57 in 10/1988
6/2002 - 11/2003	18 months	-4.13 in 3/2003	5/1999 - 4/2000	12 months	-3.69 in 4/2000
4/2012 - 11/2012	8 months +	-3.70 in 8/2012	3/2005 - 9/2006	19 months	-3.00 in 5/2006
			7/2011 - 11/2012	17 months +	-3.97 in 8/2012
WEST CENTRAL CLIMATE DIVISION 3			**SOUTHWEST CLIMATE DIVISION 4**		
Drought Periods	**Duration**	**Lowest PDSI**	**Drought Periods**	**Duration**	**Lowest PDSI**
11-1900 - 5/1902	19 months	-5.53 in 2/1902	12/1900 - 2/1902	15 months	-5.08 in 11/1901
5/1913 - 8/1914	16 months	-3.28 in 7/1914	7/1916 - 8/1918	26 months	-3.34 in 3/1918
7/1916 - 8/1918	26 months	-4.49 in 3/1918	11/1933 - 8/1934	10 months	-3.98 in 8/1934
6/1933 - 8/1934	15 months	-5.33 in 8/1934	7/1935 - 8/1936	14 months	-4.87 in 8/1936
12/1935 - 8/1936	9 months	-5.59 in 8/1936	12/1951 - 12/1956	61 months	-7.36 in 8/1954
6/1938 - 8/1941	38 months	-3.28 in 1/1940	11/1962 - 3/1965	29 months	-4.72 in 2/1964
3/1952 - 1/1957	59 months	-6.95 in 3/1954	12/1979 - 4/1981	17 months	-4.61 in 4/1981
4/1962 - 5/1965	38 months	-4.86 in 1/1964	3/2005 - 10/2006	20 months	-3.32 in 2/2006
10/1975 - 4/1977	19 months	-3.43 in 4/1977	6/2011 - 11/2012	18 months +	-3.83 in 7/2012
4/1980 - 4/1981	13 months	-4.52 in 4/1981			
6/2002 - 8/2003	15 months	-3.18 in 2/2003			
3/2005 - 11/2006	21 months	-4.04 in 9/2006			
5/2012 - 11/2012	7 months	-3.25 in 8/2012			
SOUTHWEST CLIMATE DIVISION 5			**BOOTHEEL CLIMATE DIVISION 6**		
Drought Periods	**Duration**	**Lowest PDSI**	**Drought Periods**	**Duration**	**Lowest PDSI**
12/1900 - 5/1902	18 months	-5.13 in 11/1901	10/1924 - 8/1925	11 months	-3.17 in 8/1925
4/1913 - 4/1915	26 months	-3.58 in 7/1914	2/1930 - 6/1931	17 months	-3.96 in 1/1931
9/1917 - 4/1919	20 months	-3.23 in 3/1918	7/1935 - 8/1936	14 months	-4.86 in 8/1936
2/1930 - 9/1932	32 months	-3.93 in 8/1930	5/1939 - 7/1942	39 months	-4.08 in 5/1941
6/1933 - 7/1934	14 months	-4.47 in 7/1934	12/1942 - 1/1945	26 months	-3.35 in 11/1944
12/1935 - 8/1936	9 months	-5.11 in 8/1936	4/1952 - 12/1956	57 months	-5.38 in 12/1953
9/1939 - 8/1941	24 months	-3.49 in 8/1941	11/1962 - 2/1964	16 months	-4.11 in 2/1964
7/1943 - 1/1945	19 months	-4.05 in 1/1945	10/1979 - 4/1981	19 months	-3.73 in 4/1981
5/1952 - 12/1956	56 months	-6.97 in 4/1954	2/1999 - 9/2001	32 months	-3.12 in 11/1999
4/1962 - 5/1965	38 months	-3.45 in 1/1964	2/2005 - 4/2006	13 months	-3.06 in 4/2006
11/1970 - 6/1972	20 months	-3.08 in 11/1971	3/2007 - 9/2007	7 months	-3.33 in 9/2007
9/1979 - 4/1981	20 months	-4.67 in 4/1981	2/2010 - 1/2011	12 months	-3.51 in 1/2011
5/1999 - 5/2001	25 months	-3.56 in 5/2000	2/2012 - 1/2012	10 months +	-5.07 in 8/2012
1/2012 - 11/2012	11 months	-3.80 in 8/2012			

According to the USDA Risk Management Agency, insured crop losses throughout the State of Missouri as a result of drought conditions for the fifteen year period of 1998-2012 totaled $1,530,919,292. Drought had the highest dollar amount losses for insured crops in Missouri during period. A detailed listing of insured crop losses by crop, county, and, year for insured crop losses is provided at the following link: USDA Risk Management Agency Crop Claims Data.

Measure of Probability and Severity

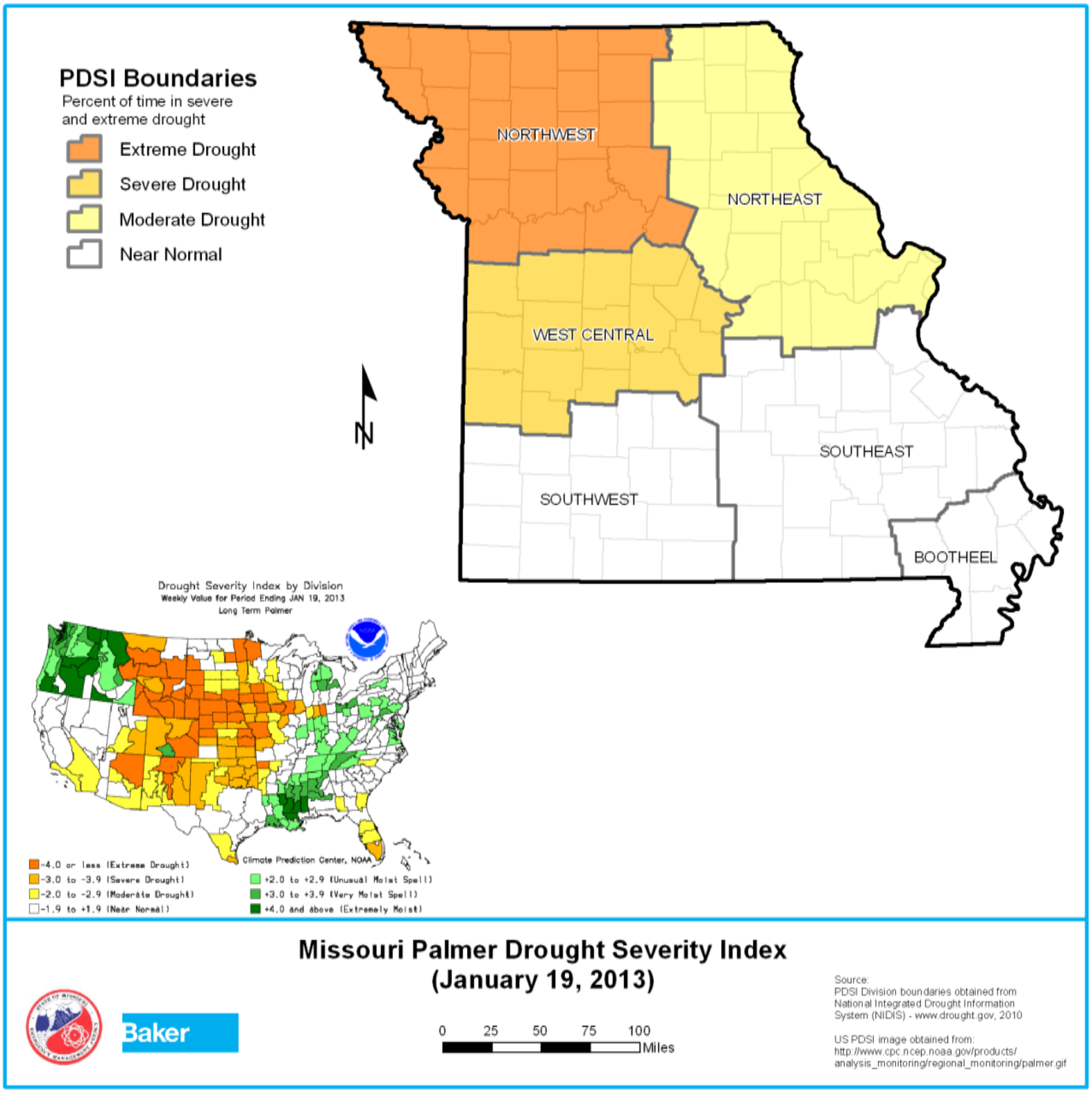
Probability: Moderate

Severity: Moderate

Because of its geographical location and characteristic weather patterns, Missouri is vulnerable to drought conditions. Agricultural droughts are the most common on record, particularly those inflicting damage to corn crop yields. Throughout much of this century, these droughts have occurred with common regularity (on the average of once every five years), according to the Missouri Crop and Livestock Reporting Service.

It is difficult to forecast the severity and frequency of future drought events in Missouri. However, two important studies were performed which provide suggest probability of future occurrence. A study by Sheffield and Wood (2007) shows that there has been relatively little change in PDSI values over the 50-year period ending in 2004. This research is interpreted to indicate that soil moisture and drought conditions can be relatively equivalent to the average PDSI values experienced over the period 1954 to 2004. In addition, based on data from 1895 to 1995, Missouri can be divided into six PDSI areas. Each of these areas have been assigned a percent of time PDSI values are less than or equal to three – a value equivalent to a drought warning or drought emergency in Missouri. Historically, X of the six sub-regions in the State are under a drought warning or emergency 5-10% of the time while X area in XY Missouri is under a drought warning or emergency 10-15% of the time. Note that these conclusions are based on past occurrences over a 100 year period which may not represent adequate statistical sampling.

Figure 3.3.9.5 – Drought Severity Index



Based on Midwest drought data, the Missouri DNR Geological Survey and Resource Assessment Division produced the Missouri Drought Response Plan in 1995 with revisions in 2002 (now the Missouri Drought Plan). The plan's primary purpose is to address the need for state and local governments to coordinate advanced emergency planning, as during the drought of 1999–2000. The plan outlines proactive emergency and tactical measures designed to better prepare the State for drought. It also emphasizes the need for long-range strategic planning, which would address the bigger issue of drought impact avoidance. The plan notes that one of the major goals of drought mitigation is to prevent water shortages in the agricultural sector and public water systems.

The Missouri Drought Plan relies primarily upon the PDSI to indicate drought severity and supports its findings directly with stream flow, reservoir-level, and groundwater-level measurements. Actions within

the drought plan are triggered when the PDSI reaches certain levels. The DAC, chaired by the director (or designee) of the DNR, is activated in the Phase II Drought Advisory stage. The DAC then activates the impact teams, which cover the topics of agriculture, natural resources and environmental recreation, water supplies, wastewater and health, social, economic, and post drought evaluations. Areas that appear to be the most vulnerable to drought are the focus of future drought planning, management, and mitigation activities. Based on this information, the State rates the probability and severity of the drought hazard as moderate.

Impact of the Hazard

A severe drought in the Southern Plains states from the fall of 1995 through the summer of 1996 resulted in approximately $5 billion in total costs and damage to agricultural regions (NCDC, 2012). The states of Texas and Oklahoma were most severely affected (NOAA, 1996). In the summer of 1993, a combination of drought and a heat wave across the southeast United States was responsible for about $1 billion in costs and damage. Among the most costly disasters, however, was the Great Drought of 1988–1989, which caused an estimated $40 billion in losses in the United States. As a comparison, the record floods of 1993 in the Midwest inflicted about $21 billion in damages. Current damage estimates for the 2011-2012 drought, which is still ongoing, range between $75 and $150 billion dollars. Although more subtle in terms of physical damage, the social and economic costs of drought are substantial Duetsche Bank Securities has predicted that this drought will be responsible for a0.5 to 1 percent drop in U.S. gross domestic product for 2012. (Freeman 2012). Figure 3.3.9.6 shows a drought stressed corn crop courtesy of MU Extension Commercial Agriculture Program.

Drought can impact navigation when water levels decline dramatically in waterways used for supply and commerce transport. The Missouri and Mississippi rivers are particularly vulnerable to drought and are monitored by the U.S. Army Corps of Engineers (USACE) and the U.S. Coast Guard (USCG) to maintain navigable paths for river traffic. USACE often conducts dredging operations and reservoir releases in order to combat the negative impacts of drought (USACE, 2012).

Figure 3.3.9.6 - Drought Stressed Corn Crop

Drought, as it affects the health and safety of Missouri citizens, is primarily a problem of rural water supply. With some exceptions, larger municipalities have not experienced major problems at levels that have caused impacts to some smaller communities. Most seriously affected are those that rely on private wells which are more likely to be impacted by water supply reductions than the public water supply. Table 3.3.9d shows the population in each county served by groundwater in 2005 according to the USGS. The counties with the highest vulnerability to drought where drinking water is concerned are Boone, Clay, Jackson, Jefferson, and St. Charles Counties, each with more than 100,000 residents dependent on private well water.

Table 3.3.9d: Population Served by Groundwater by County in 2005 (USGS-NWIS)

County	Population served by groundwater	County	Population served by groundwater
Adair County	0	Livingston County	14291
Andrew County	8388	McDonald County	7579
Atchison County	5917	Macon County	0
Audrain County	19637	Madison County	1257
Barry County	19004	Maries County	2539
Barton County	8377	Marion County	3445
Bates County	0	Mercer County	3595
Benton County	7678	Miller County	8532
Bollinger County	1832	Mississippi County	10883
Boone County	**141507**	Moniteau County	10607

Table 3.3.9d: Population Served by Groundwater by County in 2005 (USGS-NWIS)			
County	**Population served by groundwater**	**County**	**Population served by groundwater**
Buchanan County	0	Monroe County	0
Butler County	10107	Montgomery County	10040
Caldwell County	2002	Morgan County	6013
Callaway County	38360	New Madrid County	17224
Camden County	18811	Newton County	9149
Cape Girardeau County	33653	Nodaway County	2506
Carroll County	9543	Oregon County	4209
Carter County	2671	Osage County	7399
Cass County	0	Ozark County	1267
Cedar County	9133	Pemiscot County	19412
Chariton County	8124	Perry County	6797
Christian County	31351	Pettis County	11828
Clark County	7007	Phelps County	23289
Clay County	**186452**	Pike County	532
Clinton County	0	Platte County	82085
Cole County	27819	Polk County	11538
Cooper County	1732	Pulaski County	18015
Crawford County	9131	Putnam County	0
Dade County	4122	Ralls County	0
Dallas County	2971	Randolph County	0
Daviess County	5191	Ray County	23243
De Kalb County	1550	Reynolds County	1650
Dent County	8069	Ripley County	7720
Douglas County	3023	**St Charles County**	**327973**
Dunklin County	31723	St Clair County	3324
Franklin County	52699	Ste Genevieve County	10245
Gasconade County	8243	St Francois County	40291
Gentry County	2940	St Louis County	27598
Greene County	24966	Saline County	22327
Grundy County	0	Schuyler County	0
Harrison County	4468	Scotland County	0
Henry County	2153	Scott County	31461
Hickory County	2862	Shannon County	2273
Holt County	4767	Shelby County	0
Howard County	4721	Stoddard County	23616
Howell County	18420	Stone County	16367

Table 3.3.9d: Population Served by Groundwater by County in 2005 (USGS-NWIS)			
County	**Population served by groundwater**	**County**	**Population served by groundwater**
Iron County	4235	Sullivan County	0
Jackson County	**172448**	Taney County	18632
Jasper County	37689	Texas County	13674
Jefferson County	**127884**	Vernon County	19479
Johnson County	45322	Warren County	26711
Knox County	0	Washington County	5888
Laclede County	24820	Wayne County	4293
Lafayette County	7044	Webster County	11896
Lawrence County	18523	Worth County	2174
Lewis County	8965	Wright County	7696
Lincoln County	21609	St Louis City	0
Linn County	1456	**TOTAL**	**2,203,681**

In its scope, a drought may be limited to a localized problem, or even a regional problem. Based on severity and duration, it may even become a statewide problem, at least in terms of overall impact, such as the commitment and shifting of resources and other response issues. Good water quality and a plentiful supply are two factors that we often take for granted. But when good water becomes a scarce commodity and people must compete for the available supply, the importance of these two factors increases dramatically. Missouri's Resources Plan (*RSMo 640.415*), which is a provision of the Water Resources Law enacted by the Missouri Legislature in 1989, requires DNR to ensure that the quality and quantity of Missouri's water resources are maintained at the highest possible level to support present and future beneficial uses. The provision was established to provide for the development, maintenance, and periodic updating of a long-range comprehensive statewide plan for the use of surface water and groundwater. It includes existing and future requirements for drinking water supplies, agriculture, industry, recreation, environmental protection, and related needs (Missouri DNR, 2013).

The information in Table 3.3.9e is from the Impact Analysis of Potential for Detrimental Impacts of Hazards done for the Emergency Management Accreditation Program

Table 3.3.9e EMAP Impact Analysis: Drought

Subject	Detrimental Impacts
Health and Safety of Persons in the Area at Time of Incident	Most damage expected to be agricultural in nature. However, water supply disruptions may adversely affect people.
Health and Safety of Personnel Responding to the Incident	Nature of hazard expected to minimize any serious damage to properly equipped and trained personnel.
Continuity of Operations	Unlikely to necessitate execution of the Continuity of Operations Plan.
Property, Facilities, and Infrastructure	Nature of hazard expected to minimize any serious damage to facilities.
Delivery of Services	Nature of hazard expected to minimize serious damage to services, except for moderate impact on water utilities.

Subject	Detrimental Impacts
The Environment	May cause disruptions in wildlife habitat, increasing interface with people, and reducing numbers of animals.
Economic and Financial Condition	Local economy and finances dependent on abundant water supply adversely affected for duration of drought.
Regulatory and Contractual Obligations	Regulatory waivers unlikely, but permits expedited. Fulfillment of some contracts may be difficult. Impact may reduce deliveries.
Reputation of or Confidence in the Entity	Ability to respond and recover may be questioned and challenged if planning, response, and recovery not timely and effective.

Synopsis

In addition to damage to crops, produce, livestock, and soil, and the resulting economic consequences, the arid conditions created by drought pose an increased risk of fire. The danger is especially high for brush fires, grass fires, and fires in wooded areas, which can threaten homes and other structures in their path. Lack of water resources in rural areas can complicate the firefighting efforts. During the spring 2000 drought, brush and wildfires erupted in numerous counties, resulting in a governor's declared state of emergency and a presidential Fire Management Assistance declaration (NCDC, 2013). The fires in Camden County were the most severe (see Section 3.3.11 Fires).

Severe drought also poses health threats to citizens due to water shortages and extreme heat. Particularly vulnerable are children, the elderly, and those with respiratory problems. Contaminated or poor water quality for drinking and sanitation measures can also cause serious illnesses. The Missouri Drought Plan addresses issues regarding water shortages. This plan can also be accessed via the Missouri Department of Natural Resources web site at www.dnr.mo.gov/pubs/WR69.pdf.

For additional information on vulnerability to drought, see Section 3.5.9.

3.3.10 Extreme Temperature

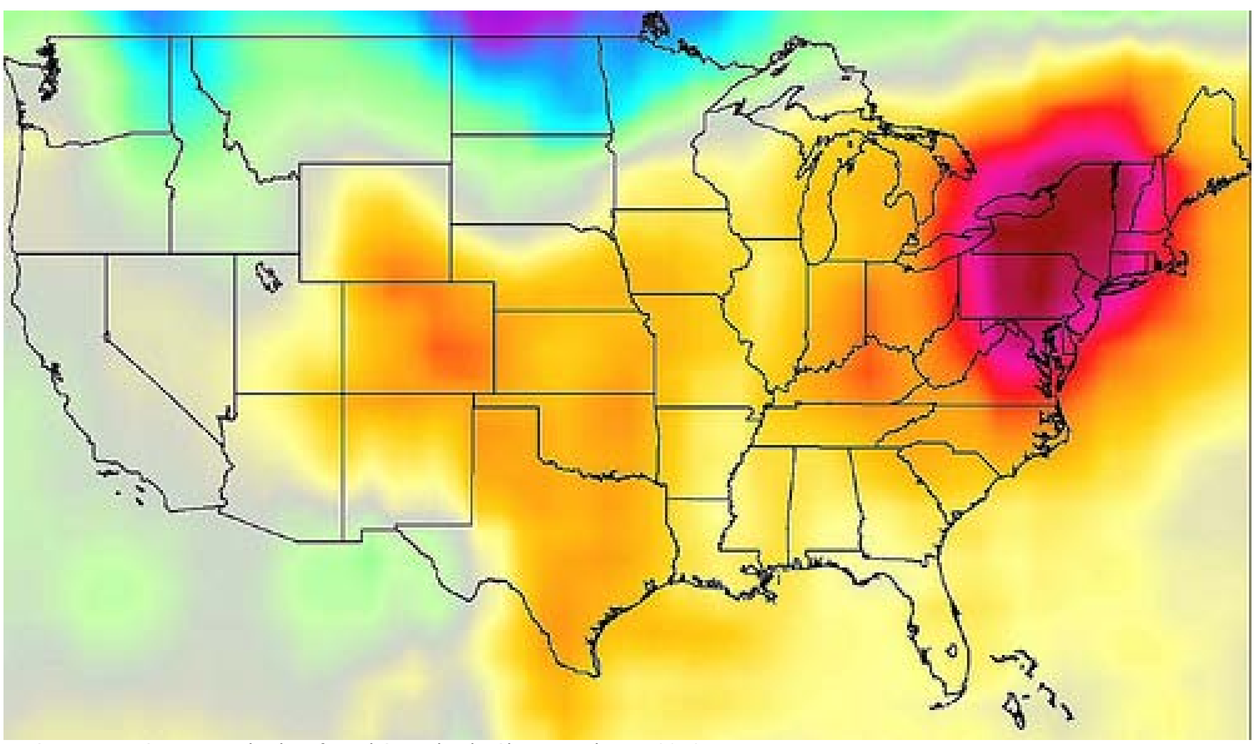
Description of Hazard

Missouri has a continental type of climate marked by strong seasonality. Frequent changes in temperature are known to occur mainly because of the State's inland location. Prolonged periods of extremely cold or hot weather are unusual however temperatures above 100° F have occurred as well temperatures below 0° F, which average 2 to 5 days per year in northern counties and 1 to 2 days per year in southern counties. (MCC 2013).

Extreme cold temperatures drop well below what is considered normal for an area during the winter months and often accompany winter storm events. Combined with increases in wind speed, such temperatures can be life threatening to those exposed for extended periods of time.

Extreme heat can be described as temperatures that hover 10°F or more above the average high temperature for a region during the summer months. A heat wave is a period of excessive heat, which can lead to illness and other stress to people with prolonged exposure to these conditions. See Figure 3.3.10.1 as an example. High humidity, which often accompanies heat in Missouri, can make the effects of heat even more harmful. While heat-related illness and death can occur from exposure to intense heat in just one afternoon, heat stress on the body has a cumulative effect. Consequently, the persistence of a heat wave increases the threat to public health.

Figure 3.3.10.1 - NASA Illustration of Heat Wave of July 2011

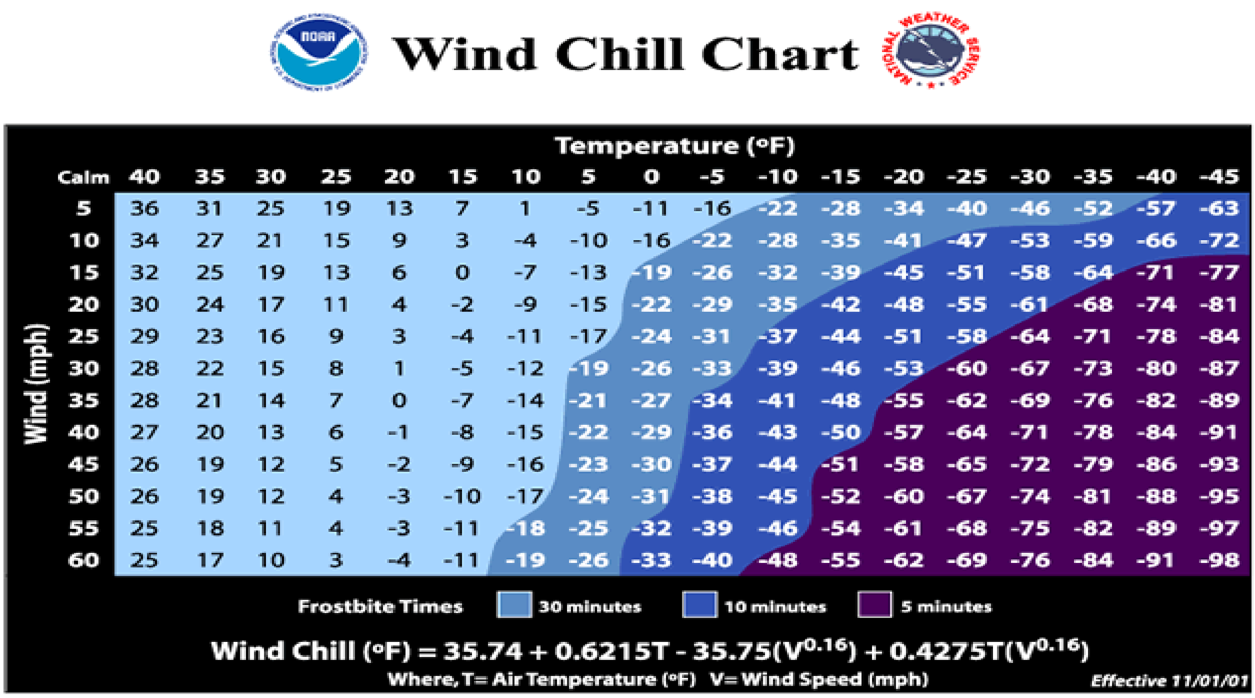


Source: NASA Atmospheric Infrared Sounder (AIS), December 7, 2012

Hypothermia or frostbite may be considered the most direct cause of death and injury that can be attributed to winter storms or severe cold. Extremely cold temperatures can produce problems. The wind chill is determined by factoring cold temperatures and wind speed to determine the overall chill factor. Figure 3.3.10.2 shows a US based map depicting an example of a heat wave based upon wind chill temperatures during the summer of 2011. For example, when the temperature is 20°F and the wind speed is 15 miles per hour, the resulting wind chill (what it really feels like) is 6°F. This type of situation can be dangerous to people outdoors because their bodies can experience rapid heat loss, resulting in hypothermia (abnormally low body temperature). Statistical information regarding hypothermia mortality is provided later in this section.

An indirect winter hazard that affects Missourians every year is carbon monoxide poisoning. Improperly vented gas and kerosene heaters or the indoor use of charcoal briquettes creates dangerous levels of carbon monoxide. There were 476 reported fatal carbon monoxide poisoning cases between 2001–2011 in Missouri according to the Missouri Department of Health and Senior Services. Accidental carbon monoxide poisonings and deaths are more likely to occur in the colder months of the year.

Figure 3.3.10.2 - Wind Chill Chart



Wind Chill Chart

Temperature (°F); Wind (mph)

Calm	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
5	36	31	25	19	13	7	1	-5	-11	-16	-22	-28	-34	-40	-46	-52	-57	-63
10	34	27	21	15	9	3	-4	-10	-16	-22	-28	-35	-41	-47	-53	-59	-66	-72
15	32	25	19	13	6	0	-7	-13	-19	-26	-32	-39	-45	-51	-58	-64	-71	-77
20	30	24	17	11	4	-2	-9	-15	-22	-29	-35	-42	-48	-55	-61	-68	-74	-81
25	29	23	16	9	3	-4	-11	-17	-24	-31	-37	-44	-51	-58	-64	-71	-78	-84
30	28	22	15	8	1	-5	-12	-19	-26	-33	-39	-46	-53	-60	-67	-73	-80	-87
35	28	21	14	7	0	-7	-14	-21	-27	-34	-41	-48	-55	-62	-69	-76	-82	-89
40	27	20	13	6	-1	-8	-15	-22	-29	-36	-43	-50	-57	-64	-71	-78	-84	-91
45	26	19	12	5	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79	-86	-93
50	26	19	12	4	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81	-88	-95
55	25	18	11	4	-3	-11	-18	-25	-32	-39	-46	-54	-61	-68	-75	-82	-89	-97
60	25	17	10	3	-4	-11	-19	-26	-33	-40	-48	-55	-62	-69	-76	-84	-91	-98

Frostbite Times: 30 minutes; 10 minutes; 5 minutes

$$\text{Wind Chill (°F)} = 35.74 + 0.6215T - 35.75(V^{0.16}) + 0.4275T(V^{0.16})$$

Where, T= Air Temperature (°F) V= Wind Speed (mph) *Effective 11/01/01*

Source: National Weather Service

According to the National Weather service heat waves consist of both abnormally high temperatures and high humidity (NWS, 2013). These high temperatures generally occur from June through September, but are most prevalent in the months of July and August. Missouri experiences about 40 days per year above 90°F, based on a 50-year average compiled by the NWS from 1961 through 2012. July and August lead this statewide mean with about 15 days above 90°F. June and September average 6 days and 3 days, respectively, for temperatures above 90°F. The 50-year climatic data is from NWS stations at

Kansas City, Columbia, Springfield, and St. Louis (NWS, 2013). As these regional locations indicate, all of Missouri is subject to heat wave during the summer months.

On July 19, 2006, after reaching a high temperature of 100 degrees, a cluster of thunderstorms, also known as a mesoscale convective system, formed across Northern Illinois and propogated southwest across West Central Illinois and Eastern Missouri. Straight line winds created widespread wind damage from Central Illinois across the St. Louis Metropolitan Area and into the Eastern Ozarks. The damage sustained in the St. Louis Metropolitan Area was consistent with wind speeds between 70 and 90 mph. Two tornado tracks were also uncovered across Southwest Illinois near the towns of Bunker Hill and Edwardsville. Over 500,000 customers were left without power, and thus no air conditioning.

A State of Emergency was declared for the St. Louis Area, and the National Guard was called in to help with heat evacuations. The temperature rose near 100 degrees once again on Thursday and heat index values were as high as 115 degrees in the affected region. (NWS MO)

The power outages caused the heat wave to have a profound effect on individuals residing within the impacted area (CNN, 2006). By July 31, 2006, 10 heat-related deaths had been reported in Jefferson County, St. Louis City, and St. Louis County. This incident accounted for nearly half of the total 25 heat-related deaths that occurred in Missouri in 2006 (Missouri DHSS, 2011).

Along with humans, animals also can be affected by high temperatures and humidity. For instance, cattle and other farm animals respond to heat by reducing feed intake, increasing their respiration rate, and increasing their body temperature. These responses assist the animal in cooling itself, but this is usually not sufficient. The hotter the animal is, the more it will begin to shut down body processes not vital to its survival, such as milk production, reproduction, or muscle (meat) building (Dewell, 2010).

Ambient temperature is not the only factor that should be considered when assessing the likely effects of heat. Relative humidity must also be considered along with duration of exposure, wind, and activity. The NWS has stepped up its efforts to more effectively alert the general public and appropriate authorities to the hazards of heat waves—those prolonged episodes of excessive heat and humidity. The NWS has devised a Heat Index (HI), which is a combination of air temperature and relative humidity that more accurately reflects the heat intensity.

The HI, given in degrees Fahrenheit, is an accurate measure of how hot it really feels when the relative humidity (RH) is added to the actual air temperature. The Heat Index Chart is shown in Figure 3.3.10.3. As an example, if the air temperature is 96°F (found on the left side of the table), and the relative humidity is 55 percent (found at the top of the table), the HI is 112°F (the intersection of the 96°F row and the 55 percent column). Because HI values were devised for shady, light wind conditions, exposure to full sunshine can increase HI values by up to 15°F. Also, strong winds, particularly with very hot, dry air, can be extremely hazardous.

Figure 3.3.10.3 - Heat Index Chart

NOAA's National Weather Service

Heat Index

Temperature (°F)

Relative Humidity (%)	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
40	80	81	83	85	88	91	94	97	101	105	109	114	119	124	130	136
45	80	82	84	87	89	93	96	100	104	109	114	119	124	130	137	
50	81	83	85	88	91	95	99	103	108	113	118	124	131	137		
55	81	84	86	89	93	97	101	106	112	117	124	130	137			
60	82	84	88	91	95	100	105	110	116	123	129	137				
65	82	85	89	93	98	103	108	114	121	128	136					
70	83	86	90	95	100	105	112	119	126	134						
75	84	88	92	97	103	109	116	124	132							
80	84	89	94	100	106	113	121	129								
85	85	90	96	102	110	117	126	135								
90	86	91	98	105	113	122	131									
95	86	93	100	108	117	127										
100	87	95	103	112	121	132										

Likelihood of Heat Disorders with Prolonged Exposure or Strenuous Activity

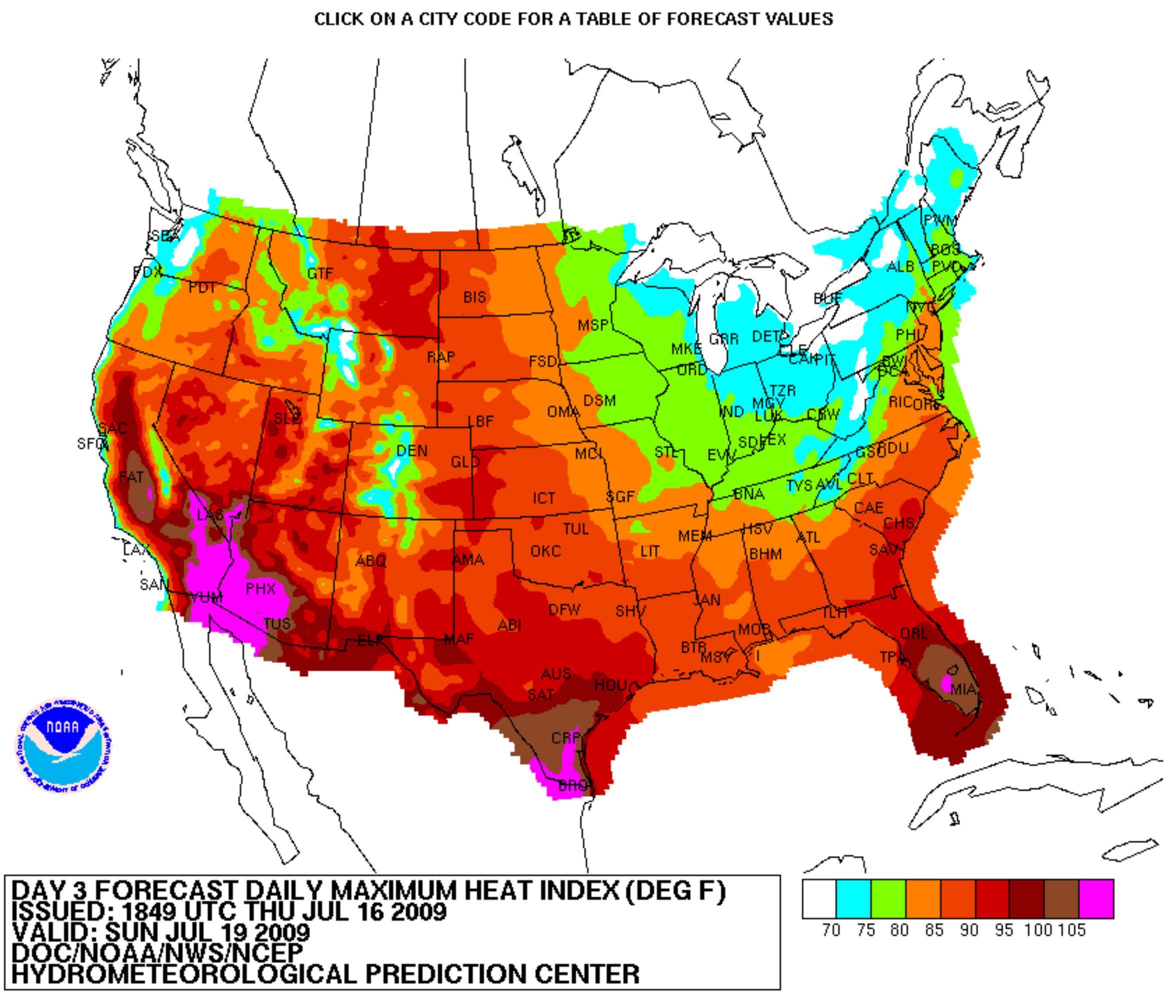
Caution Extreme Caution Danger Extreme Danger

Source: NWS, 2013

*Note: On the HI chart, the shaded zone above 105°F corresponds to a level that may cause increasingly severe heat disorders with continued exposure or physical activity.

The National Weather Service will issue warnings when the heat index is predicted to reach dangerous levels. Maps such as the one shown in Figure 3.3.10.4 below show the maximum heat index for each state across the county (NWS, 2009). Heat waves are often a major contributing factor to power outages (brownouts, etc.), as the high temperatures result in a tremendous demand for electricity for cooling purposes. Power outages for prolonged periods increase the risk of heat stroke and subsequent fatalities due to loss of cooling and proper ventilation.

Figure 3.3.10.4 - Heat Index Map



Other related hazards include water shortages brought on by drought-like conditions and high demand. Local advisories, which list priorities for water use and rationing, are common during heat waves. Government authorities report that civil disturbances and riots are also more likely to occur during heat waves, as well as incidents of domestic violence and abuse. In cities, pollution becomes a problem because the heat traps pollutants in densely developed urban areas. Adding pollution to the stresses of the heat magnifies the health threat to the urban population (NGN, 2010).

Historical Statistics

Heat kills by taxing the human body beyond its abilities. In the 40-year period 1936 through 1975, nearly 20,000 people died in the United States from the effects of heat and solar radiation. Some of the worst years for heat-related deaths occurred during the Great Depression, with 843 deaths in 1934, and 644 in 1936. The worst year in the past few decades was 1980, with 1,250 deaths from excessive heat (NWS, 2005).

Each year many Missourians suffer from heat-related illnesses, with some cases resulting in death. During prolonged periods of high temperatures, using air conditioning – either at home or by seeking shelter in a local cooling center -- is the best preventive measure.

The Missouri Department of Health and Senior Services (DHSS) monitors high temperatures and humidity across the State to prevent heat-related illness and death. The elderly and the chronically ill are more vulnerable to the effects of high temperatures. They perspire less and are more likely to have health problems requiring medications that can impair the body's response to heat. Many prescription medications make individuals more sensitive to the heat. Some of these medications include heart drugs, some anti-Parkinsonian agents, antihistamines, over-the-counter sleeping pills, antidepressants, anti-psychotics and major tranquilizers.

DHSS initiated statewide hyperthermia death surveillance in 1980 in response to a summer heat wave that resulted in the death of 295 individuals. The program defines hyperthermia as physician-diagnosed heat exhaustion, heat stroke, or hot weather/natural environment as a contributing factor in a death. In 2005 and 2006, 25 Missourians died each year from heat-related illnesses. Missouri's heat-related deaths are primarily in the urban, more densely populated areas of St. Louis City, St. Louis County, and Jackson County (Kansas City) (Missouri DHSS, 2013).

In August 2007, Missouri experienced a heat wave that lasted approximately 21 days and resulted in 34 hyperthermia deaths. The heat wave started August 2 with a heat index of 101 in Cape Girardeau and spread across the State. By August 7, the five cities that DHSS receives daily heat data on from the National Weather Service were experiencing heat indices of 103 or higher. The heat index remained in the upper 90s or higher in at least one of the five areas until August 25.

Public and private emergency response plans were implemented across the State. These responses included opening cooling centers, distributing ice, water, and people checking door-to-door for persons in danger from the heat. Without this quick and intensive response, public health officials believe mortality from the August 2007 heat wave would have been much greater. Fortunately, hot weather during the summer of 2008 was much more sporadic and less prolonged, resulting in 10 deaths statewide.

In 2012, an intense heat wave plagued the Midwest, setting record maximum temperatures in both St. Louis and Columbia in Missouri. The heat wave began at the end of June and extended past the July 4th holiday, occurring during a drought that ranged in severity from moderate to severe. In the St. Louis metropolitan area, 18 heat-related deaths occurred in total (NWS, 2012).

According to the USDA Risk Management Agency, insured crop losses throughout the State of Missouri as a result of excessive heat for the eleven year period of 1998 – 2008 totaled $13,751,457. Excessive heat ranked 6th in the State for insured crop losses. From 2000 to 2010, drought and heat were the source of about 31% of the crop losses in Missouri by indemnity payments (Milhollin, 2012). Also, hot winds in Missouri totaled $885,893 in insured crop losses from the same timeframe. A detailed listing of insured crop losses by crop, county, and, year for insured crop losses is provided at the following link: http://www.rma.usda.gov/tools/

Extreme cold can also result in death and injury. The following summaries describe some of the most extreme cold weather events that have impacted Missouri.

January 14–20, 1994: Northeast, central, and east-central Missouri experienced overnight low temperatures from below zero to –20°F. Hundreds of homes and businesses had frozen and busted water pipes. Wind chills, which ranged from -30 to -50°F, kept schools closed and accounted for 15 people being admitted to local hospitals for hypothermia and frostbite.

January 10–13, 1997: Northwest and west-central Missouri experienced overnight low temperatures below zero. No record low temperatures were recorded, but winds gusting up to 30 miles per hour produced afternoon wind chills as low as -30 to -50°F.

According to the USDA Risk Management Agency, insured crop losses throughout the State of Missouri as a result of cold wet winter, cold winter, freeze, and frost conditions for the eleven year period of 1998 – 2008 totaled $20.9 million. A detailed listing of insured crop losses by crop, county, and, year for insured crop losses is provided at the following link: USDA Risk Management Agency Crop Claims Data.

Measure of Probability and Severity
Probability: Moderate
Severity: Moderate
Prolonged periods of extremely cold or hot weather are unusual however temperatures above 90° F have occurred as well temperatures below 0° F, which average 2 to 5 days per year in northern counties and 1 to 2 days per year in southern counties. Based on 50-year statistics from the NWS indicating the State's mean number of days above 90°F, Missouri is vulnerable to heat waves in July and August. The NWS has developed a Heat Index/Heat Disorder Chart that relates ranges of HI with specific disorders, particularly for people in higher risk groups.

Table 3.3.10a Heat Index/Heat Disorder Chart

Heat Index	Heat Disorder
130°F or higher	Heat stroke or sunstroke highly likely with continued exposure.
105 to 129°F	Sunstroke, heat cramps, or heat exhaustion likely, and heat stroke possible with prolonged exposure or physical activity.
90 to 104° F	Sunstroke, heat cramps, and heat exhaustion possible with prolonged exposure or physical activity.
80 to 89°F	Fatigue possible with prolonged exposure or physical activity.

Source: National Weather Service, 2013

Table 3.3.10b shows the three response levels developed by the NWS, based on the Heat Index, to alert the public to the potential heat hazards:

Table 3.3.10b Heat Index Response Levels

Heat Index	Response Level
Issued within 12 hours of the onset of the following criteria: heat index of at least 105°F for more than 3 hours per day for 2 consecutive days, or heat index more than 115°F for any period of time	Warning/Advisory
Issued by the National Weather Service when heat indices in excess of 105ºF (41ºC) during the day combined with nighttime low temperatures of 80ºF (27ºC) or higher are forecast to occur for two consecutive days.	Watch
Issued when potential exists for an excessive heat event in the next 3 to 7 days. An outlook is used to indicate that a heat event may develop. It is intended to provide information to those who need considerable lead time to prepare for the event, such as public utilities, emergency management and public health officials	Outlook

Source: National Weather Service, 2013

Based on information from DHSS and the NWS, the State rates the probability of a heat wave as high, due to the frequency of heat-related illness and death, and severity as moderate, because only a small portion of the population is impacted.

In 2003, the city of St. Louis Missouri debuted a heat watch-warning system to give city residents notice before severe heat events. DHSS will announce a statewide hot weather health alert when the conditions are as follows:

Table 3.3.10c Missouri Department of Health and Senior Services Hot Weather Alerts

Type of Alert	Conditions of Alert
Hot Weather Health Alert	Heat indices of 105°F in a large portion of the State are first reached (or predicted).
Hot Weather Health Warning	Heat indices have been 105°F or more for two days in a large portion of the State, or weather forecasts call for continued heat stress conditions for at least 24 to 48 hours over a large portion of the State.
Hot Weather Health Emergency	When extensive areas of the State meet the following criteria: (1) High sustained level of heat stress (HI 105°F for 3 days); (2) increased numbers of heat-related illnesses and deaths statewide, and (3) the NWS predicts hot, humid temperatures for the next several days for a large portion of the State.

Source: Missouri Department of Health and Senior Services

Impact of the Hazard

The severity of heat disorders tends to increase with age. Heat cramps in a 17-year-old can become heat exhaustion for someone in their forties and may result in a fatal stroke for someone in their sixties. Table 3.3.10d lists conditions associated with heat, their symptoms, and suggested first aid.

Table 3.3.10d Heat Disorders/Symptoms/First Aid

Heat Disorder	Symptoms	First Aid
Sunburn	Redness and pain. In severe cases, swelling of skin, blisters, fever, and headaches.	Apply ointment for mild cases if blisters appear. If breaking occurs, apply dry sterile dressing. Serious, extensive cases should be seen by physician.
Heat Cramps	Painful spasms possible usually in muscles of legs and abdomen. Heavy sweating.	Apply firm pressure on cramping muscles, or gentle massage to relive spasms. Give sips of water.
Heat Exhaustion	Heavy sweating and weakness; cold, pale and clammy skin. Pulse thread. Normal temperature possible. Fainting and vomiting.	Get victim out of sun. Lie down and loosen clothing. Apply cool wet cloths. Fan or move victim to air conditioned room. Give sips of water. If vomiting continues, seek immediate medical attention.
Heat Stroke (or Sunstroke)	High body temperature (106°F, or higher). Hot dry skin. Rapid and strong pulse. Possible unconsciousness.	Heat stroke is a severe medical emergency. Summon medical assistance or get the victim to a hospital immediately. Delay can be fatal. Move the victim to cooler environment. Reduce body temperature with cold bath or sponging. Use extreme caution. Remove clothing. Use fans and air conditioners. If temperature rises again, repeat process. Do not give fluids.

Source: NWS, 2013

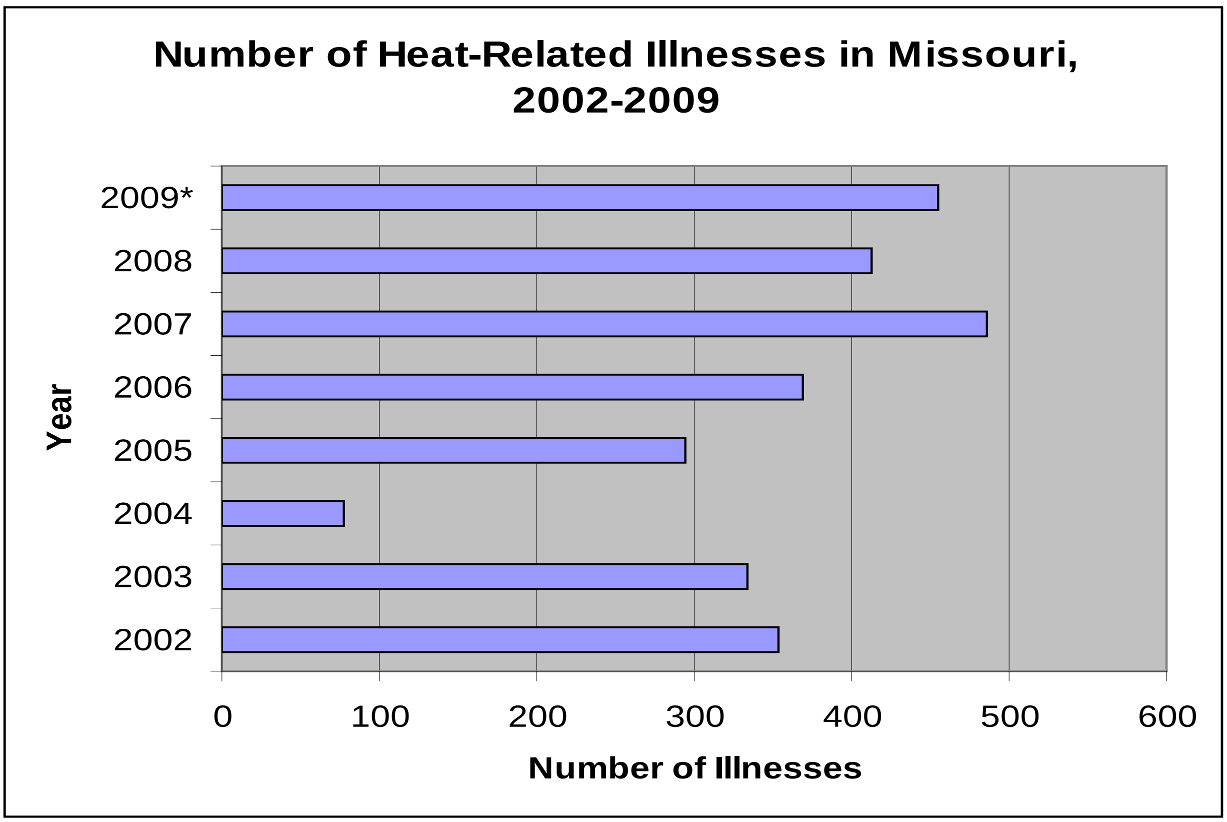
The following population groups are at a greater risk to becoming very sick from heat waves (Bouchama, 2007):

- Those vulnerable to heat stress due to physical condition
  - Older people
  - Children
  - People overweight or underweight
- People with limited independence due to physical or mental disorders
  - People in institutional settings without air conditioning
  - People working in heat under stress (firefighters, police, emergency medical technicians)
  - People in urban environments where heat retention in asphalt, concrete, and masonry is a factor (heat island effect)
  - People with low income who lack resources for air conditioning, transportation, medical care, etc.

- Those with increased risk from work or leisure activities
  - People who work outdoors (utility crews, construction crews, etc.)
  - Military personnel and trainees
  - Athletes
- Those more difficult to reach through normal communications
  - People who live alone
  - People who are homeless
  - People who do not speak English
  - People who cannot read
  - People who are culturally, socially, or geographically isolated

Even when a heat injury isn't fatal, it can be extremely serious and require lifelong monitoring of further exposure to heat. Besides mortality statistics due to heat, the Missouri DHSS track heat-related injuries. Figure 3.3.10.5 shows heat-related illnesses in Missouri from 2002-2009. A graphic showing heat related mortality in Missouri is available in Section 3.3.10.5.

Figure 3.3.10.5 - Number of Heat-Related Illnesses in Missouri, 2002-2009



*2009 data is provisional

Source: Missouri Department of Health and Senior Services

As previously mentioned, animals can be adversely affected by heat stress. This poses a risk to farmers, ranchers, and the entire state, which relies on agricultural revenue to keep the economy strong.

Livestock producers cannot afford to ignore the effects of high temperatures on their herds. The following symptoms are signs of heat stress on livestock (USDA, 2007):

- Restlessness and crowding under shade or at water tanks/areas
- Open-mouthed breathing or panting and increased salivating
- Increased respiration rates
- Gasping and lethargic demeanor

Heat stress is evident in the cattle shown in figure below, as they are exhibiting several symptoms such as open-mouthed breathing and increased salivation. (See Figure 3.3.10.6)

Figure 3.3.10.6 - Heat Stress in Cattle

Source: USDA, 2007.

The information in Table 3.3.10e is from the Impact Analysis of Potential for Detrimental Impacts of Hazards done for the Emergency Management Accreditation Program.

Table 3.3.10e EMAP Impact Analysis: Heat Wave

Subject	Detrimental Impacts
Health and Safety of Persons in the Area at Time of Incident	Localized impact expected to be severe for unprotected personnel and moderate to light for protected personnel.
Health and Safety of Personnel Responding to the Incident	Nature of hazard expected to minimize any serious damage to properly equipped and trained personnel.
Continuity of Operations	Unlikely to necessitate execution of the Continuity of Operations Plan.

Subject	Detrimental Impacts
Property, Facilities, and Infrastructure	Nature of hazard expected to minimize any serious damage to facilities.
Delivery of Services	Extent of agricultural damage depends on duration. Water supplies and electricity may be disrupted.
The Environment	May cause disruptions in wildlife habitat, increase interface with people, and reduce numbers of animals.
Economic and Financial Condition	Local economy and finances dependent on stable electricity and water supply adversely affected for duration of heat wave.
Regulatory and Contractual Obligations	Regulatory waivers likely unnecessary. Fulfillment of some contracts and deliveries may be difficult if electricity and water disrupted.
Reputation of or Confidence in the Entity	Ability to manage situation may be questioned and challenged if planning and response not timely and effective.

Hypothermia: Hypothermia is defined as a cold injury associated with a fall of body temperature to less than 94.1ºF, which results from unintentional exposure to a cold environment.

The most common symptoms of hyperthermia are as follows:

- Uncontrollable shivering. In severe cases of hypothermia, shivering stops
- Numbness
- Glassy stare
- Apathy
- Weakness
- Impaired judgment
- Drowsiness
- Slow or slurred speech
- Exhaustion
- Loss of consciousness
- In infants, the skin turns bright red and cold
- Infants with a very low energy level

The information in Table 3.3.10f is from the Impact Analysis of Potential for Detrimental Impacts of Hazards done for the Emergency Management Accreditation Program.

Table 3.3.10f EMAP Impact Analysis: Severe Winter Weather

Subject	Detrimental Impacts
Health and Safety of Persons in the Area at Time of Incident	Localized impact expected to be severe for affected areas and moderate to light for other less affected areas.
Health and Safety of Personnel Responding to the Incident	Adverse impact expected to be severe for unprotected personnel and moderate to light for trained, equipped, and protected personnel.
Continuity of Operations	Unlikely to necessitate execution of the Continuity of Operations Plan.
Property, Facilities, and Infrastructure	Localized impact to facilities and infrastructure in the areas of the incident. Power lines and roads most adversely affected.
Delivery of Services	Localized disruption of roads and/or utilities caused by incident may postpone delivery of some services.
The Environment	Environmental damage to trees, bushes, etc.
Economic and Financial Condition	Local economy and finances may be adversely affected, depending on damage.
Regulatory and Contractual Obligations	Regulatory waivers may be needed locally. Fulfillment of some contracts may be difficult. Impact may temporarily reduce deliveries.
Reputation of or Confidence in the Entity	Ability to respond and recover may be questioned and challenged if planning, response, and recovery not timely and effective.

Synopsis

Many people do not realize how dangerous a heat wave or cold spell can be.

In contrast to the visible, destructive, and violent nature of floods, hurricanes, and tornadoes, a heat wave is a "silent killer." Be aware of the warning signs of heat-related illness, such as light-headedness, mild nausea or confusion, sleepiness, or profuse sweating. To prevent heat-related illness, take the following precautions (Missouri DHSS, 2013):

- Increase your fluid intake; drink more liquids than your thirst indicates.
- Drink nonalcoholic and caffeine-free liquids, such as water and juices.
- Wear lightweight, light-colored, loose-fitting clothing.
- When unaccustomed to working or exercising in a hot environment, start slowly and pick up the pace gradually; rest frequently in a shady area.
- Spend time in an air-conditioned place; if not at home, then spend time in such public places as libraries, supermarkets, shopping malls, and movie theatres.
- Do not rely on fans as your primary cooling devices during a heat wave.
- Schedule outdoor activities carefully, preferably before noon or in the evening.

- When working in the heat, monitor the condition of your coworkers and have someone do the same for you.
- Monitor those at high risk, such as the elderly, infants, and children up to four years of age, someone who is overweight, or someone on medication.
- Ask your physician whether you are at particular risk because of medication.
- Do not leave infants, children, or pets unattended in a parked car or other hot environments.

Although fans are less inexpensive to operate, they may not be effective, and may even be harmful when temperatures are very high. As the air temperature rises, airflow is increasingly ineffective in cooling the body until finally, at temperatures above 100°F (the exact number varies with the humidity); increasing air movement actually increases heat stress. More specifically, when the temperature of the air rises to about 100°F, the fan may be delivering overheated air to the skin at a rate that exceeds the capacity of the body to get rid of this heat, even with sweating, and the net effect is to add heat rather than to cool the body. An air conditioner, if one is available, is a much better alternative (Missouri DHSS, 2013). More information on heat-related illness is available through the DHSS web page at www.dhss.mo.gov/Hyperthermia/index.html.

Extreme cold can also be life threatening. In order to avoid injury or death due to hypothermia, the following precautions may be taken (Missouri DHSS, 2013):

- Call 911 for immediate medical assistance
- Gently move the victim to a warm place
- Monitor the victim's blood pressure and breathing
- If needed, give rescue breathing and CPR
- Remove wet clothing
- Dry off the victim
- Take the victim's temperature
- Warm the body core first, NOT the extremities. Warming the extremities first can cause shock. It can also drive cold blood toward the heart and lead to heart failure.
- DO NOT warm the victim too fast. Rapid warming may cause heart arrhythmias

For additional information on vulnerability to extreme temperature, see Section 3.5.10.

3.3.11 Fires (Structural, Urban, and Wild)

Description of Hazard

Fires can range in scope to include structural fires, urban fires, and wildfires. For the purpose of this analysis, structural and urban fires are considered in one category, with wildfires, including forest, prairie, and grassland locations, are considered separately. An example of wildfire is shown in Figure 3.3.11.1.

Figure 3.3.11.1 - Wildfire in Crawford County, Easter Sunday, 1998

Photo Courtesy of Jim Lyon, mofire.org

Structural and Urban Fire

Urban fire hazards incorporate vehicle and building/structure fires as well as overpressure rupture, overheat, or other explosions that do not ignite. This hazard occurs in denser, more urbanized areas statewide and most often occurs in residential structures (US Fire Administration, 2009). Urban fires can more easily spread from building to building in these denser areas. Urban fires and explosions often begin as a result of other hazards, particularly storms, lightning strikes, drought, transportation accidents, hazardous materials releases, criminal activity (arson), and terrorism. Structural fires are a major problem that can affect any area of the State. The Missouri Division of Fire Safety (MDFS) indicates that approximately 80 percent of the fire departments in Missouri are staffed with volunteers dedicated to the task of fire prevention and suppression (UME, 2009). Whether paid or volunteer, these departments are often limited by lack of resources and financial assistance.

The impact of a fire to a single-story building in a small community may be as great as that of a larger fire to a multistory building in a large city.

Because fires can occur anywhere in the State, the MDFS continues to actively promote the enactment of a statewide fire code. Although no statewide code has been enacted to date, successful legislative efforts to improve fire safety have included the following:

- Fire, Safety, Health, and Sanitation Inspections of Child Care Facilities (RSMo 210.252)
- Boiler and Pressure Vessel Safety Act (RSMo 650.200)
- Elevator Safety Act (RSMo 701.350)
- Fireworks Safety Act (RSMo 320-111)
- Amusement Ride Safety Act (RSMo 316.200-211)
- Inspections of Long Term Care Facilities (RSMo 198.074)
- Missouri Blasting Safety Act (RSMo 319.300) (MO SOS, 2013)

Fires impact many aspects of society in terms of economic, social, and other indirect costs. According to the MDFS, the most costly crime in the State is arson. This should be a great concern to citizens, law enforcement, the judicial system, and the fire service sector. Fires caused by arson impact citizens through higher insurance premiums, lost jobs, loss of lives, injuries, and property loss. Primary duties of the State fire marshal include the investigation of fires, explosions, and any related occurrences. The investigative staff is responsible for investigating any fire requested by fire service and law enforcement within the State. This also includes explosions, bombings, and all other related offenses (MDFS, 2013).

Presently, the MDFS investigative staff includes 1 deputy chief, 2 regional chiefs and 15 field investigators. This staff must cover all 114 counties and is dedicated to assisting any local or state agency and conducting quality investigations. The investigators are trained in several fields of expertise, including arson for fraud, explosives recognition, and post blast training. The Division uses four canine teams, two canines specifically trained in explosives detection and two trained in the detection of accelerants. Another tool utilized by the investigation unit is the Computerized Voice Stress Analyzer (MDFS, 2013).

The MDFS Training Unit develops and oversees the training curriculum being provided regionally for state certification of firefighters, fire investigators, fire inspectors, and fire service instructors. Although firefighter certification is not mandatory in Missouri, currently over 28,000 individuals have been awarded over 71,000 certifications by the MDFS (MDFS, 2013).

Also, the MDFS coordinates a statewide fire mutual aid system. This system enhances the ability of volunteer or career fire departments to handle major fires or incidents within their jurisdictions. To complement the Statewide fire mutual aid system, an incident support team (IST) concept has been developed in regions of the State. The teams are available to assist agencies in the management of major fires and manmade or natural disasters. Figure 3.3.11.2 (below) shows the Fire/Rescue Mutual Aid Regions in Missouri (MO-IMAS, 2011).

Figure 3.3.11.2 - Missouri Fire and Mutual Aid Regions

Source: MO-IMAS, 2011

The MDFS is responsible for the enforcement of fireworks laws throughout Missouri. In addition to conducting inspections of any facilities involved with fireworks, approximately 1,350 permits are issued yearly to manufacturers, wholesalers, and retailers of fireworks. Persons conducting public fireworks shows are required to obtain a fireworks operator license issued by the MDFS. Illegal fireworks are a concern, because they can be dangerous, causing loss of lives, severe injuries, and property damage (MDFS, 2012).

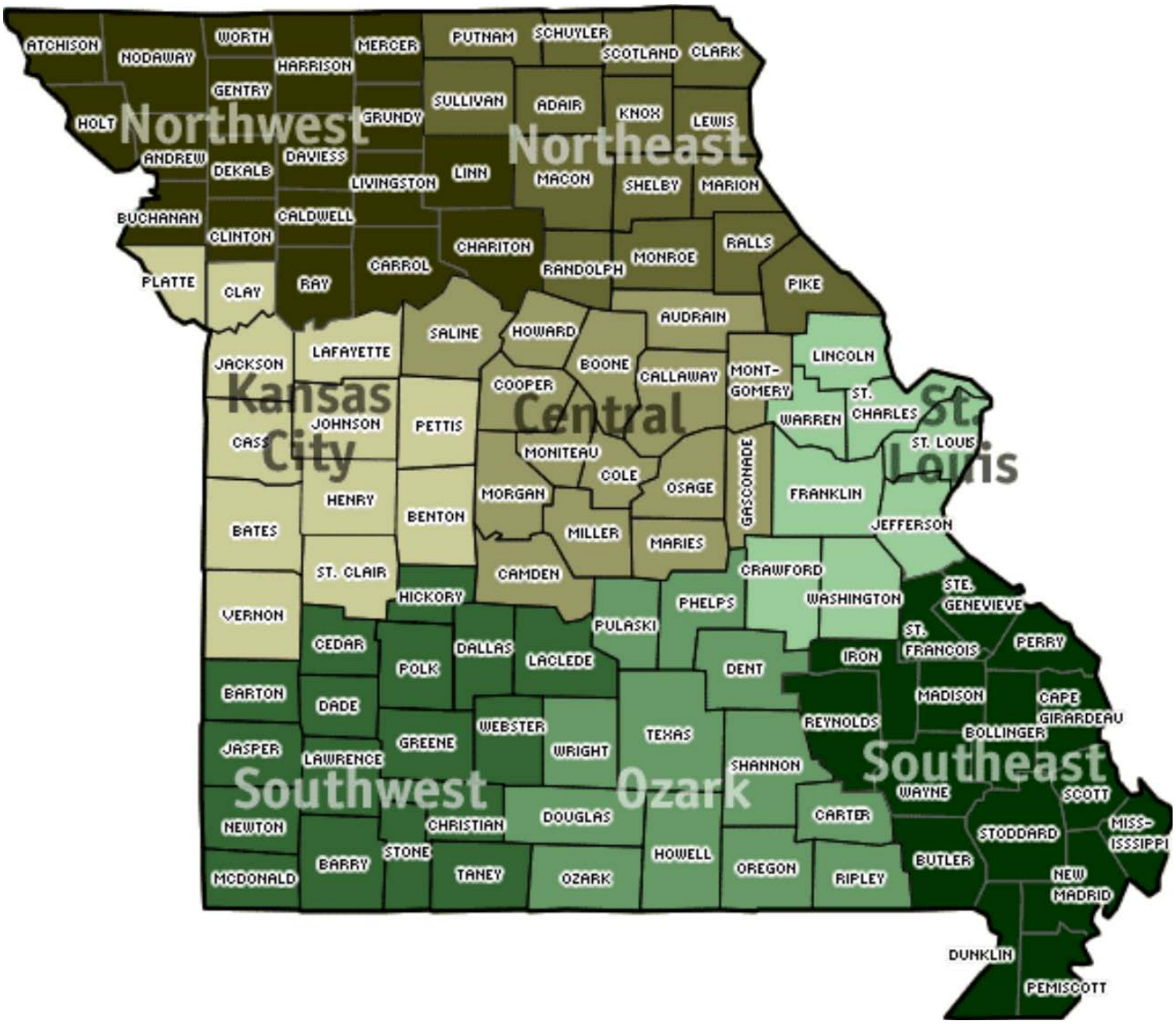
In general, the current extensive networks of roads and streets coupled with the number of local fire departments should provide relatively swift access to fire events. It is anticipated that blockage by damage, debris, and operations will be localized and temporary. However, urban fires have the potential to cause extensive damage to residential, commercial, or public property. Damage ranges from minor smoke and/or water damage to the destruction of buildings. People are often displaced for several months to years depending on the magnitude of the event. Urban fires and explosions can also cause injuries and death.

Wildfire

Wildfires occur throughout wooded and open vegetation areas of Missouri They can occur any time of the year, but mostly occur during long, dry hot spells. Any small fire, if not quickly detected and suppressed, can get out of control. Most wildfires are caused by human carelessness or negligence. However, some are precipitated by lightning strikes and in rare instances, spontaneous combustion.

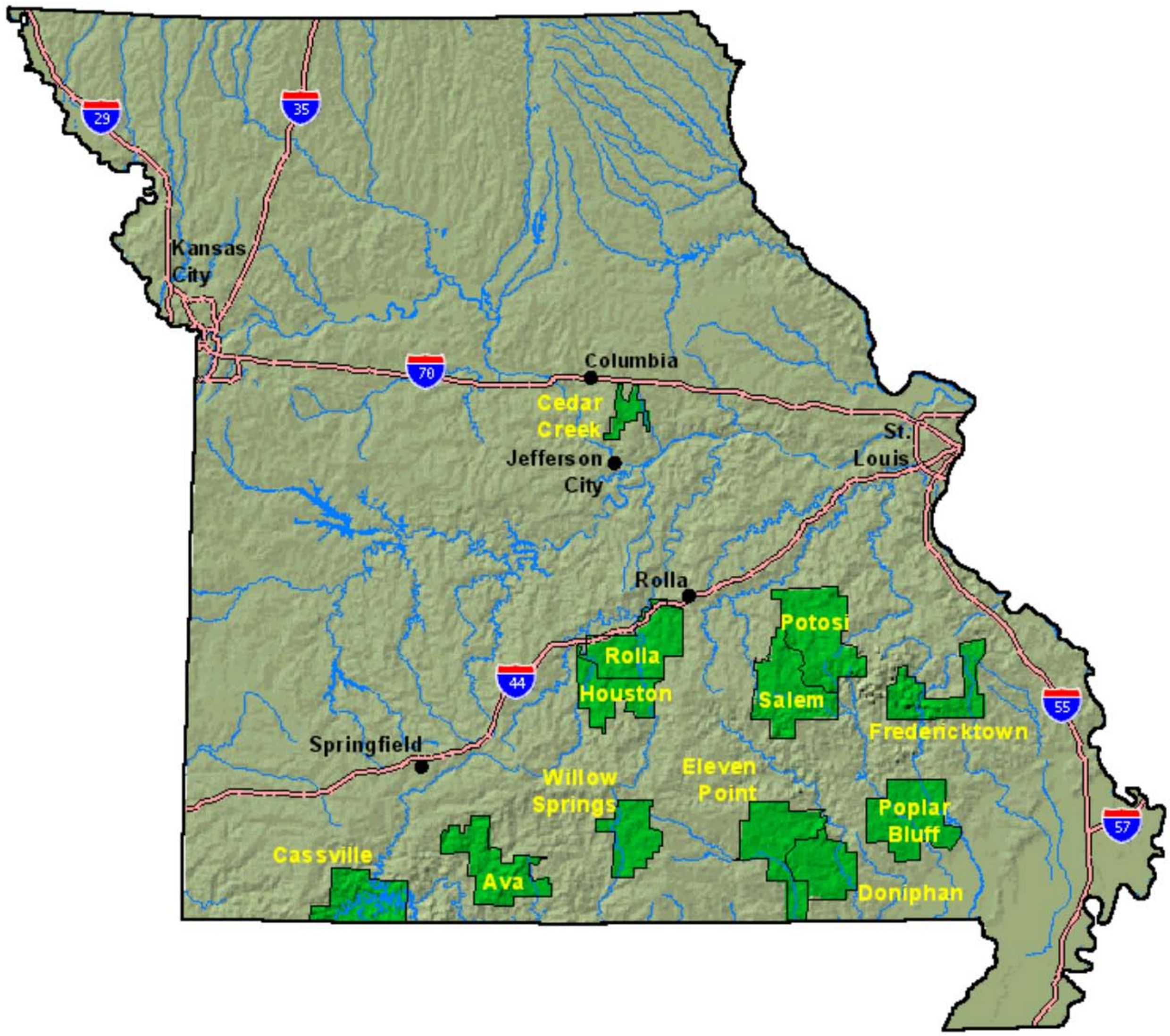
The Forestry Division of the Missouri Department of Conservation (MDC) is responsible for protecting privately owned and state-owned forests and grasslands from the destructive effects of wildfires. To accomplish this task, eight forestry regions have been established in the State to assist with the quick suppression of fires. The Forestry Division works closely with volunteer fire departments and federal partners to assist with fire suppression activities. Currently, more than 900 rural fire departments operate in Missouri in concert with the MDC (Krepps, 2003). Many have mutual aid agreements with the Forestry Division to obtain assistance in wildfire protection if needed; a cooperative agreement with the Mark Twain National Forest is renewed annually. The Mark Twain National Forest also has a cooperative agreement with the Ozark-St. Francis National Forest in order to support one another with initial attack fire suppression and to share information about fire training (EACC, 2005) Figure 3.3.11.4 illustrates the Mark Twain National Forests across Missouri.

Figure 3.3.11.3 - Missouri Department of Conservation Forestry Regions



Source: Missouri Department of Conservation, 2012.

Figure 3.3.11.4 - Mark Twain National Forests



Source: Missouri Department of Conservation

Open fields, grass, dense brush and forest-covered areas are typical sites for wildfire events. Forest and grassland fires can occur any day throughout the year. Each year, an average of about 3,100 wildfires burn more than 53,000 acres of forest and grassland in Missouri (MDC, 2013). Most of the fires occur during the spring season, normally between February 15 and May 10. The length and severity of burning periods largely depend on the weather conditions. Spring in Missouri is noted for its low humidity and high winds. These conditions, together with below-normal precipitation and high temperatures, result in extremely high fire danger. In addition, due to the continued lack of moisture throughout many areas of the State, conditions are likely to increase the risk of wildfires. Under dry conditions or droughts, wildfires have the potential to burn forests as well as croplands. Drought conditions can also hamper firefighting efforts, as decreasing water supplies may not provide for adequate firefighting suppression. Spring is when many rural residents burn their garden spots, brush piles, and other areas. This is also a

time when bare trees allow sunlight to reach the forest floor, drying fallen leaves and other ground debris. Some landowners also believe it is necessary to burn their forests in the spring to promote grass growth, kill ticks, and reduce brush. Therefore, with the possibility of extremely high fire dangers and the increased opportunities for fires, the spring months are the most dangerous for wildfires. The second most critical period of the year is fall, when dried leaves are also fuel for fires. Depending on the weather conditions, a sizeable number of fires may occur between mid-October and late November.
In north and west-central Missouri, the MDC has limited firefighting forces. Forestry Division personnel, however, provide training and limited federal excess equipment to the many volunteer rural fire departments. See Figure 3.3.11.3 for a map of the MDC forestry regions.

Historical Statistics

Structural and Urban Fire

Because buildings exist anywhere people live and work, fires can occur at anytime and anyplace throughout the State. The frequency of structural fires depends on a wide range of factors. These factors include, but are not limited to, population or building density, building use, lack of fire codes, lack of enforcement when fire codes exist, fire safety practices (or lack thereof) by building occupants, lack of adequately equipped fire departments, and criminal intent related to arson.

Do to the limitations the available reports and a summary of events could not be developed. However, data on the frequency of structural fires is included in the National Fire Incident Reporting System Statistics (NFIRS) data provided by the MDFS at nfirs.fema.gov. Out of nearly 900 fire departments in the State, approximately 61 percent of those are registered in the NFIRS system and are actively participating by reporting data used to compile the NFIRS (USFA, 2009). Without 100 percent reporting, definitive conclusions are not possible; however, fire departments, law enforcement offices, and other agencies spend considerable manpower and funding to respond to and investigate structural fires. Additional information on NFIRS can be found at http://www.dfs.dps.mo.gov/programs/resources/fire-incident-reporting-system.asp.

Table 3.3.11a Missouri Structural Fire Statistics (2002-2012)

Year	Total Fires	Total Fire Dollar Loss	Fire Related Injuries	Fire Related Deaths
2002	19,749	$ 80,184,764	225	39
2003	22,097	$ 68,193,344	272	48
2004	30,731	$103,699,511	371	86
2005	24,182	$ 99,120,053	319	51
2006	29,865	$1,238,056,662	377	70
2007	27,324	$4,156,015,816	375	70
2008	24,647	$9,343,081,187	12	68
2009	25,795	$2,399,531,780	287	57
2010	24,785	$6,132,675,694	382	78
2011	22,429	$127,256,829	288	50
2012	19,293	$4,152,595,091	317	44

Source: NFIRS

Data records of structural fire causes for each county from 2009-2012 are available from NFIRS, however are not included in this update.

Wildfire

At the present time, the forestry districts provide fire protection to approximately one-half of the State, or about 16 million acres. Within these districts, fairly accurate forest and grassland fire statistics are available from the MDC. In a typical year, approximately 3,100 wildfires occur.

In 2012, 5,306 wildfires occurred in Missouri, burning 89,150 acres. Debris burning (fires resulting from land clearing, burning trash, range, stubble, right-of-way, logging slash, etc.) is the major known cause of forest and grass fires in Missouri. Incendiary fires (fires willfully set by anyone on property not owned or controlled by him and without the consent of the owner) continue to account for a significant number of wildfires that occur each year; typically, 40 percent of forest fires each year are caused by arson (CCM, 2013).

Table 3.3.11b lists the number and causes of forest and grassland fires in 2012 and the acres burned. Table 3.3.11c shows the number of fires and acreage burned by forest and grassland fires yearly from 1993 to 2012. Additional information on reporting of wildfires can be found at http://mdc4.mdc.mo.gov/applications/FireReporting/Report.aspx.

Table 3.3.11b 2012 Statewide Forest and Grassland Fires by Cause

Cause	Number	Acres	% Number	% Acres
Lightning	37	247	0.7	0.3
Campfire	73	438	1.4	0.5
Smoking	90	548	1.7	0.6
Debris	1,754	22,649	33.1	25.4
Arson	250	12,992	4.7	14.6
Equipment	421	5057	7.9	5.7
Railroad	14	20	0.3	0.1
Children	37	109	0.7	0.1
Miscellaneous	678	9,933	12.8	11.1
Unknown	1,832	33,745	34.5	37.8
Not Reported	120	3,412	2.2	3.8
Totals	5,306	89,150	100	100

Source: Missouri Department of Conservation, 2013

Table 3.3.11c Statewide Forest and Grassland Fires and Acres Burned, 1993–2012

Year	Fires	Acres
1993	2,994	31,952
1994	2,748	51,896
1995	2,910	48,907
1996	3,793	88,933
1997	2,487	29,557
1998	1,112	10,415
1999	1,348	18,270
2000	4,910	132,718
2001	2,972	41,092
2002	2,376	54,397
2003	2,378	47,692
2004	2,917	55,732
2005	1,610	38,921
2006	3,553	52,419
2007	3,058	36,922
2008	2,825	37,534
2009	5,384	88,911
2010	2,798	32,864
2011	4,195	80,925
2012	5,306	89,150

Source: Missouri Department of Conservation

Despite the fact that Missouri experiences an average of 3,100 wildfires each year, Missouri has only received one fire management assistance declaration. This was for the Camden Fire Complex in 2000. At the time of the declaration, the complex consisted of 70 fires burning on 3,000 acres of grassland that had destroyed 17 homes and forced the evacuation of approximately 300 residents in Camden County communities from Macks Creek to Climax Springs (FEMA, 2000). Additional county-level historical data is available in Section 3.5 to support further vulnerability and loss estimation as it varies across the State.

Measure of Probability and Severity

Structural and Urban Fire

Probability: High

Severity: Moderate

Many factors contribute to the cause of structural and urban fires. Due to the various factors, urban areas in Missouri are considered at risk to one degree or another. Minor urban fires can be expected often in Missouri. Major fires will continue to occur several times a year, particularly in dense, urban

areas with aging building stock. However, the probability of future occurrences may decrease with the construction of new buildings to building codes that address fire prevention, detection, and extinguishments. Also, continued efforts to increase public awareness of the dangers of urban fires will help to mitigate injury, death, and property loss. The probability of future occurrence may increase in communities whose populations are growing and where new areas are developed.

Even with the limited data in the NFIRS statistics, the probability of structural fires is high. Total monetary loss in 2012, according to the NFIRS, was over $4.1 billion. In addition, there were 44 fire-related deaths in Missouri during 2012. In 2009, the fire mortality rate was approximately 20.2 deaths per million residents, or about 120 fire-related deaths per year. This is the 6th highest fire mortality rate in the nation and is higher than the national average of 11.0 deaths per million residents (US Fire Administration, 2009) Therefore, severity could be considered high.

Wildfire
Probability: Moderate
Severity: Low to Moderate
Wildfire events can range from small fires that can be managed by local firefighters to large fires impacting many acres of land. Large events may require evacuation from one or more communities and necessitate regional or national firefighting support. The impact of a severe wildfire can be devastating. A wildfire has the potential to kill people, livestock, fish and wildlife. The severity in Missouri would be considered low to moderate.

They often destroy property, valuable timber, forage and recreational and scenic values. In addition to the risk wildfires pose to the general public and property owners, the safety of firefighters is also a concern. Although loss of life among firefighters does not occur often in Missouri, it is always a risk. More common firefighting injuries include falls, sprains, abrasions or heat-related injuries such as dehydration. Response to wildfires also exposes emergency responders to the risk of motor vehicle accidents and can place them in remote areas away from the communities that they are chartered to protect.

Wildfire events will occur in Missouri every year. The probability of wildfires (forest, prairie, and grassland) is considered moderate overall, but may increase to high during certain periods, such as spring or late fall, or under conditions of excessive heat, dryness, or drought. However, the likelihood of one of those fires attaining significant size and intensity is unpredictable and highly dependent on environmental conditions and firefighting response.

Due to the high percentage of wildfires caused by arson, the occurrence of future wildfire events will strongly depend on patterns of human activity. Events are more likely to occur in wildfire-prone areas experiencing new or additional development.

Impact of Hazard
The impact of structural and urban fire events vary based on the size of the incident and the population and structure density where it occurs. There may be environmental impacts related to hazardous materials when a fire event or explosion releases dangerous materials.

There are additional economic consequences related to this hazard. Urban fires and explosions may result in lost wages due to temporarily or permanently closed businesses, destruction and damage

involving business and personal assets, loss of tax base, recovery costs, and lost investments in destroyed property.

The secondary effects of urban fire and explosion events relate to the ability of public, private, and non-profit entities to provide post-incident relief. Human services agencies (community support programs, health and medical services, public assistance programs and social services) can be affected by urban fire and explosion events as well. Effects may consist of physical damage to facilities and equipment, disruption of emergency communications, loss of health and medical facilities and supplies, and an overwhelming load of victims who are suffering from the effects of urban fire, including the loss of their home or place of business.

Vegetation loss due to wildfire is often a concern, but it typically is not a serious impact since natural re-growth occurs with time. The most significant environmental impact of wildfire is the potential for severe erosion, silting of stream beds and reservoirs, and flooding due to ground-cover loss following a fire event. Wildfires also have a positive environmental impact in that they burn dead trees, leaves, and grasses to allow more open spaces for new and different types of vegetation to grow and receive sunlight. Another positive effect of a wildfire is that it stimulates the growth of new shoots on trees and shrubs and its heat can open pine cones and other seed pods.

Structural and urban fires are a daily occurrence throughout the State. Roughly 100 fatalities occur annually, as well as numerous injuries affecting the lives of the victims, their families, and many others—especially those involved in fire and medical services (NFIRS, 2013). Unlike other disasters, structural fires are often insidious and despicable due to the prevalence of arson. All citizens pay the costs of arson whether through increased insurance rates, higher costs to maintain fire and medical services, or the costs of supporting the criminal justice system.

The information below is from the Impact Analysis of Potential for Detrimental Impacts of Hazards done for the Emergency Management Accreditation Program.

Table 3.3.11d EMAP Impact Analysis: Fires

Subject	Detrimental Impacts
Health and Safety of Persons in the Area at Time of Incident	Localized impact expected to be severe for incident areas and moderate to light for other adversely affected areas.
Health and Safety of Personnel Responding to the Incident	Localized impact expected to limit damage to personnel in the incident areas at the time of the incident.
Continuity of Operations	Damage to facilities/personnel in the area of the incident may require temporary relocation of some operations.
Property, Facilities, and Infrastructure	Localized impact to facilities and infrastructure in the area of the incident. Some severe damage possible.
Delivery of Services	Localized disruption of roads and/or utilities caused by incident may postpone delivery of some services.
The Environment	Localized impact expected to be severe for incident areas and moderate to light for other areas affected by smoke or HazMat remediation.
Economic and Financial Condition	Local economy and finances may be adversely affected, depending on damage and length of investigations.

Subject	Detrimental Impacts
Regulatory and Contractual Obligations	Regulatory waivers may be needed locally. Fulfillment of some contracts may be difficult. Impact may temporarily reduce deliveries.
Reputation of or Confidence in the Entity	Ability to respond and recover may be questioned and challenged if planning, response, and recovery not timely and effective.

Synopsis

With sufficient mutual aid, local fire services have adequate day-to-day fire service capabilities. The greatest risk of interaction by fires with other hazards may involve damaging earthquakes. In these circumstances, the possibility of numerous fires and reduced firefighting capabilities would greatly increase the severity of structural fires.

For additional information on vulnerability to fire, see Section 3.5.11.

3.3.12 CBRNE Attack (Chemical, Biological, Radiological, Nuclear or high yield Explosive)

Description of Hazard

Of all the possible disasters and hazards that can be imagined, a strategic CBRNE (Chemical, Biological, Radiological, Nuclear or high yield Explosive) attack could have the most devastating and far-reaching consequences. The use of these weapons against the United States is unlikely; however, as long as such weapons exist, there is always a chance that they could be used. The potential for traditional war-related attacks, using conventional weapons, is a scenario that is more likely to occur, based on currently available information.

Although the threat of all-out nuclear war has been significantly reduced with the dissolution of the former Soviet Union, several scenarios still exist that might subject a jurisdiction to widespread radioactive contamination or high-levels of radiation exposure. When Phase II of the START II Treaty[21] (passed by the U.S. Senate in 1996 and ratified by the Russian Duma in April 2000) is complete, it will allow its signatories, Russia and the United States, to maintain only between 3,000–3,500 actual (versus accountable in the START) strategic nuclear weapons each, a significant reduction from Cold War numbers. In a February 2009 report to the Senate Select Committee on Intelligence[22], Dennis C. Blair, Director of National Intelligence stated,

> "….we judge Beijing seeks to modernize China's strategic forces in order to address concerns about the survivability of those systems in the face of foreign, particularly US, advances in strategic reconnaissance, precision strike, and missile defenses. We assess China's nuclear capabilities will increase over the next ten years."

According to the same report, five other nations have declared their nuclear capability and another five are suspected of having developed nuclear weapon technology, including trouble spots, North Korea and Iran. Additionally, 15 nation states have either had weapons or programs to develop nuclear weapons but have reportedly abandoned their efforts. Most have now signed the nuclear nonproliferation treaty. The U.S. Department of Defense estimates that as many as 26 nations may possess chemical agents or weapons, and an additional 12 may be seeking to develop them. The Central Intelligence Agency reports that at least 10 countries are believed to be conducting research on biological agents for weaponization.

While the threat of nuclear attack has diminished over the past several years, concerns over the use of chemical and biological warfare agents have increased. Recent events, such as the September 11, 2001, terrorist attacks on the World Trade Center buildings in New York City and the Pentagon in Washington DC, along with the anthrax-related attacks in 2001, have increased both the public and the policy maker's awareness of the vulnerability of the United States to future attacks involving CBRNE. For more information on terrorism-related issues, see Section 3.3.20.

In his February 2009 report, Director of National Intelligence Blair also reported the ongoing efforts of nation-states to develop and/or acquire dangerous weapons and delivery systems in the Middle East and elsewhere constitute another major threat to the safety of our nation, our deployed troops, and our allies. He said that the US is most concerned about the threat and destabilizing effect of nuclear

[21] http://www.fas.org/nuke/control/start2/index.html
[22] http://intelligence.senate.gov/090212/blair.pdf

proliferation. The threat from the proliferation of materials and technologies that could contribute to both existing and prospective biological and chemical weapons programs also is real. According to Blair, most of the international community shares these concerns.

> "Over the coming years, we will continue to face a substantial threat, including the US Homeland, from terrorists attempting to acquire biological, chemical, and possibly nuclear weapons and use them to conduct large-scale attacks"[23]
>
> Dennis C. Blair
> Director of National Intelligence

Historical Statistics[24]

Between 960–1279 AD arsenical smoke (a form of chemical warfare) was used in battle during China's Sung Dynasty, and in 1346–1347, Mongols catapulted corpses (biological warfare) contaminated with plague over the walls into Kaffa (in Crimea), forcing besieged Genoans to flee.

[25]During World War I (1915–1918), chemical and conventional weapons were used. The first poison gas, chlorine, was used by the Germans against Allied troops in 1915. The effects of the gas were devastating, causing severe choking attacks within seconds of exposure. The British subsequently retaliated with chlorine attacks of their own, although reportedly more British suffered than Germans, because the gas blew back into their own trenches. Phosgene was later used in the war because it caused less severe coughing, resulting in more of the agent being inhaled. Then, in September 1917, mustard gas was used in artillery shells by the Germans against the Russians. Mustard gas caused serious blisters, both internally and externally, several hours after exposure. In all, there were 1,240,853 gas-related casualties and 91,198 deaths from gas exposure during World War I.

During World War II (1941–1945), atomic (nuclear), chemical, and conventional weapons were used. Use of chemical weapons in World War II was not as prevalent as in World War I and was primarily limited to the Japanese Imperial Army[26]. During the war, the Japanese used various chemical-filled munitions, including artillery shells, aerial bombs, grenades, and mortars, against Chinese military forces and civilians. Chemical agents used included phosgene, mustard, lewisite, hydrogen cyanide, and diphenyl cyanarsine. The war was brought to an abrupt end in 1945, when the United States dropped two atomic bombs on Japan: one on Hiroshima that obliterated the entire city and killed approximately 66,000 people and another on Nagasaki that destroyed about half the city and killed about 39,000 people.

During the Vietnam War (1964–1973)[27], chemical and conventional weapons were used. Chemical weapons used during the Vietnam War are believed to have only involved tear agents used by the United States and possibly psychedelic agents, also by the United States. Although not directly used as warfare agents, toxic herbicides such as Agent Orange were commonly used as defoliants by the United States. Long-term exposure to Agent Orange, which contained the contaminant dioxin, was believed to cause illness and disease in humans.

---

[23] http://www.intelligence.senate.gov/pdfs/11162.pdf
[24] http://www.stimson.org/topics/biological-chemical-weapons/
[25] http://www.firstworldwar.com/weaponry/gas.htm
[26] www.fas.org/nuke/guide/japan/cw
[27] http://www.fas.org/programs/bio/index.html

In 1983, Iraq launched its first of 10 documented chemical attacks against Iran. The largest of these attacks was in February 1986, when mustard gas and the nerve agent tabun were used, impacting up to 10,000 Iranians. Although the exact number of chemical attacks implemented by Iraq during the war is unknown, the Iranian government estimates that more than 60,000 soldiers had been exposed to mustard gas and the nerve agents sarin and tabun by the time the war ended in 1988. Based on these data, the Iraqi chemical attacks during the Iran-Iraq war were the largest since World War I.

In 2007 a graduate student threatened the University of Missouri-Rolla with the claim of a bomb and anthrax. This threat shut down the university for several hours and canceled classes for the day. While it ultimately proved to be false threats from a disgruntled student, police encountered him holding a bag, claiming it was a bomb and armed with a knife. After decontaminating the student and clearing the dorms it was determined that no evidence of anthrax existed.

In 2012, a robot was used to inspect and eliminate an IED at Lone Pine Trailer Park in Pettis County near Sedalia. County Sherriff were service routine arrest warrants when they spotted a handgun in a nearby parked car. While retrieving the weapon the sheriff spotted the IED and immediately cleared the area. The state police bomb squad handled the elimination of the IED.

Although several isolated attacks involving biological agents have occurred over the last few decades, a series of incidents in the United States that gained nationwide exposure occurred between early October and early December 2001, when five people died from anthrax infection, and at least 13 others contracted the disease in Washington, DC; New York City; Trenton, New Jersey; and Boca Raton, Florida. Anthrax spores were found in a number of government buildings and postal facilities in these and other areas. Most of the confirmed anthrax cases were tied to contaminated letters mailed to media personalities and U.S. senators. Thousands of people were potentially exposed to the spores and took preventive antibiotics. Numerous mail facilities and government buildings were shut down for investigation and decontamination. In the wake of these incidents, federal, state, and local emergency response agencies across the United States responded to thousands of calls to investigate suspicious packages, unknown powders, and other suspected exposures. Fortunately, almost all of these incidents turned out to involve no actual biohazard.

The National Counterterrorism Center (NCTC) has established a Worldwide Incidents Tracking System[28] for Weapons of Mass Destruction incidents at http://wits.nctc.gov. The following are brief descriptions of Chemical, Biological, Radiological, Nuclear, and high-yield Explosive (CBRNE) related incidents that have occurred in the United States between 2004-2009.

> **February 2, 2004**: In Washington, DC, ricin was discovered in a United States Senator's Office. Fortunately there were no reports of illness or injury. No group claimed responsibility.
>
> **March 14, 2005:** Trace amounts of potential anthrax were found at a Department of Defense mail facility in Washington, DC. Workers were given antibiotics as a precautionary measure. No injuries or damages were reported and no group claimed responsibility.

[28] http://www.terrorismanalysts.com/pt/index.php/pot/article/view/88/html

May 5, 2005: In New York City, New York, two small improvised explosive devices (IEDs) exploded outside of the building housing the British Consulate, causing damage, but no injuries. No group claimed responsibility.

October 26, 2007: In New York City, New York, an unknown assailant threw two explosive devices into the compound of the Mexican Consulate causing minor damage, but no injuries. No group claimed responsibility.

December 12, 2008: At about 5:30 pm in Woodburn, Oregon, an improvised explosive device (IED) located at a bank exploded killing two police officers, and injuring another police officer and a bank employee. The bank was damaged. No group claimed responsibility.

The United States Bomb Data Center, a division of the Bureau of Alcohol, Tobacco, Firearms and Explosives maintains information about explosives incidents in each state. The following data in Table 3.3.12a is for Missouri from 2004 to 2007.

Table 3.3.12a Explosives Incidents in Missouri (2004-2007)

	2004	2005	2006	2007	2010	2011	2012
Bombings	20	11	28	13	24	46	32
Attempted Bombings	6	0	0	2	-	-	-
Incendiary Bombings	3	2	4	1	46	317	391
Total Injured	1	0	3	0	23	46	106
Total Killed	2	0	0	0	16	15	49
Total Incidents of Thefts of Explosives	2	4	2	5	1	3	-

Source: United States Bomb Data Center; http://www.atf.gov/explosives/groups/usbdc/ & ATF's BATS database.

Information on more recent events has been limited as national security has made it harder to access attack data.

Measure of Probability and Severity

Probability: Low

Severity: High

Attacks against the United States as a whole, and against individual states or local entities, can be categorized as originating from either domestic or international sources. However, because the impacts on life and property would largely be the same regardless of the source of such an attack, similar preparedness, response, and recovery activities apply.

CBRNE weapons have often been used to terrorize an unprotected population, instead of actual use as weapons of war. However, the potential damage that can occur in the event of such an attack is extensive, particularly to human health.

A single nuclear weapon detonation could cause widespread destruction, and all aforementioned types of attacks could cause extensive casualties. It could affect the entire population in the vicinity of the impacted area, and some areas would experience direct weapons effects: blast, heat, and initial nuclear

radiation. Other areas would experience indirect weapons effects, primarily radioactive fallout. As long as world leaders maintain rational thinking, the probability of an attack by a nation-state remains low, but does not rule out attack by a terrorist group.

Secondary effects of these attacks, which could strain the country and state, include lack of adequate shelter, food, water, health and medical facilities and personnel, and mortuary services; disruption of communication systems; power outages and other critical infrastructures. Because of the potential devastation and significant secondary effects caused by this type of attack, the severity is rated high.

Effects of the Hazard

The population is vulnerable to two separate categories of effects associated with these types of attacks: direct and indirect. For more information on these effects, which are often connected to terrorist-related activities, see Section 3.3.20.

Direct Effects

These are effects directly associated with detonation or use of the weapon.

Conventional Weapons—Direct effects of conventional weapons generally are related to injuries inflicted by penetration of ammunition rounds or shrapnel from exploding ordnance (mortars, etc.). Injuries from shock waves/blast overpressure near the targets may also occur, along with damage caused by fires produced from incendiary warheads, grenades, and other munitions. In addition, some injuries may occur as a result of flying or falling debris where the weapons are used. Heavy artillery use can also damage roadways and buildings and disrupt utility services for lengthy periods of time.

Chemical and Biological Weapons—Direct effects of chemical weapons involve initial spread of agents and fragmentation of the weapons. Chemical agents are toxins used to produce neurological and pulmonary injuries or death. Biological agents are infectious microbes used to produce illness or death. They can be dispersed as aerosols or airborne particles directly onto a population, producing an immediate effect (a few seconds to a few minutes for chemical agents) or a delayed effect (several hours to several days for biological agents). Severity of injuries depends on the type and amount of the agent used and duration of exposure. Because some biological agents take time to grow and cause disease, an attack using this type of agent may go unnoticed for several days.

Nuclear Weapons—Direct effects include intense heat, blast energy, and high-intensity nuclear radiation. These effects generally will be limited to the immediate area of the detonation (up to 22 miles), depending on weapon size, altitude of burst, and atmospheric conditions.

Agroterrorism—The direct effect of agroterrorism is the intentional introduction of a contagious animal disease or fast spreading plant disease that affects livestock and food crops and disrupts the food supply chain. Agroterrorism could cause disease in livestock, crops, and in some cases (anthrax, or monkey pox, for example), humans. Diseases that can be transmitted to humans from animals are called zoonotic. It would not only require the agriculture industry to destroy livestock and food crops, but also affect the consumer confidence in the food supply resulting in tremendous economic damage for, potentially, an extended period. The food supply could be severely affected not only for the immediate area and the United States, but the world market, since the United States exports huge quantities of food to other nations. Recently, the federal government recognized the vulnerability of the agricultural/food supply

industry and potential debilitation from a terrorist incident and acted to protect the resources through presidential decision directives and encouraged complementary state and local actions.

Radiological Weapon—Direct effects of a radiological weapon are the same as a conventional high explosive, but with the added danger posed by exposure to radiological materials. A radiological dispersion device (RDD) or “dirty bomb” will contaminate an area by spreading radiological dust and debris over a large area.

Explosive Weapon (large amount of high explosive)—The direct results of an explosive weapon are immense destruction caused by the blast and could result in multiple fatalities. Instances of these effects include Oklahoma City, Kobhar Towers, the marine barracks in Lebanon, and the African Embassy bombings.

Indirect Effects

These are effects not directly associated with the detonation and use of the weapon.

Conventional Weapons—Unexploded ordinance throughout a battle zone or explosion hazards to those in the area can persist after warfare has ended. Many conventional munitions also contain toxic compounds that can leach into surrounding soils and groundwater if left in place.

Chemical and Biological Weapons—Indirect effects are generally limited to downwind areas. They can be geographically widespread and vary in intensity—depending on weapon size, type of chemical or biological agent, and wind patterns. The spread of these agents can contaminate food and water supplies, destroy livestock, and ravage crops.

Nuclear Weapons—When a nuclear weapon detonates, intense heat, blast, and overpressure will cause severe injuries and fatalities in the surrounding area and radiation poisoning at more distant locations. A detonation near or on the ground draws up large quantities of earth and debris into a mushroom cloud. This material becomes radioactive, and the particles can be carried by wind hundreds of miles before they drop back to earth as “fallout.” In an attack, many areas of the United States would probably escape fallout altogether or experience non life-threatening levels of radiation. However, because weather that determines where fallout will land is so unpredictable, no locality in the United States is free from risk of receiving deadly radiation levels after a strategic attack. Less than lethal exposures will result in longer-term effects on health and contamination of food, water, and food production.

Agroterrorism—Agroterrorism’s indirect effects are loss of breeding stock to replenish herds and flocks, loss of seed crops, and possibly loss of land use for a long period of time depending on the disease involved. Agroterrorism has a high probability of creating an economic disaster for states highly vested in food production, and potentially the nation.

Radiological Weapon—The indirect effect of an RDD is inability to use the contaminated area for a short to long period of time, depending on the identity of the radioactive material. Because radioactive material from an RDD can penetrate wood, asphalt, concrete, and masonry (and radioactive dust and particles can enter the smallest crevices), decontamination will be extremely difficult or impossible.

Explosive Weapon (large amount of high explosive)—The indirect effect of an explosive weapon is the fear, terror, and lasting psychological damage to survivors and other individuals.

The information in Table 3.3.12b is from the Impact Analysis of Potential for Detrimental Impacts of Hazards done for the Emergency Management Accreditation Program.

Table 3.3.12b EMAP Impact Analysis: Attack

Subject	Detrimental Impacts
Health and Safety of Persons in the Area at Time of Incident	Adverse impact expected to be severe for unprotected personnel and moderate to light for protected personnel.
Health and Safety of Personnel Responding to the Incident	Adverse impact expected to be severe for unprotected personnel and moderate to light for trained and protected personnel.
Continuity of Operations	Damage to facilities/personnel in the area of the incident may require relocation of operations and lines of succession execution.
Property, Facilities, and Infrastructure	Damage to facilities and infrastructure in the area of the incident may be extensive for explosion, moderate to light for HazMat.
Delivery of Services	Disruption of lines of communication and destruction of facilities may extensively postpone delivery of services.
The Environment	May cause extensive damage, creating denial or delays in the use of some areas. Remediation needed.
Economic and Financial Condition	Local economy and finances adversely affected, possibly for an extended period of time.
Regulatory and Contractual Obligations	Regulatory waivers may be needed. Fulfillment of contracts may be difficult. Demands may overload ability to deliver.
Reputation of or Confidence in the Entity	Ability to respond and recover may be questioned and challenged if planning, response, and recovery not timely and effective.

Synopsis

Even though the START treaty has reduced the overall number of nuclear weapons, and many chemical/biological weapons stockpiles have been destroyed, we must continue to plan for, and be prepared for, this type of hazard. In many ways, while the risk of a nuclear exchange by the super powers is greatly reduced, the potential risk of proliferation of weapons of mass destruction is greater than during the Cold War era due to the number of potential material sources increasing.

While it may be challenging to prevent such an attack, steps can be taken to lessen the likelihood and the potential effects of an incident by implementing certain measures:

- Identifying and organizing resources:
- Conducting a risk or threat assessment and estimating losses:
- Identifying mitigation measures that will reduce the effects of the hazards and developing strategies to deal with the mitigation measures in order of priority:
- Implementing the measures and evaluating the results (and keeping the plan up-to-date).

For additional information on vulnerability to attack, see Section 3.5.12.

3.3.13 Civil Disorder

Description of Hazard[29]

Civil disorder is a term that generally refers to groups of people purposely choosing not to observe a law, regulation, or rule, usually in order to bring attention to their cause, concern, or agenda. In Missouri, state statutes define civil disorder as "any public disturbance involving acts of violence by assemblages of three or more persons, which cause an immediate danger of or results in damage or injury to the property or person of any other individual."

Civil disorder can take the form of small gatherings or large groups blocking or impeding access to a building or disrupting normal activities by generating noise and intimidating people. They can range from a peaceful sit-in to a full-scale riot in which a mob burns or otherwise destroys property and terrorizes individuals. Even in its more passive forms, a group that blocks roadways, sidewalks, or buildings interferes with public order. In the 1990s, abortion clinics, for example, were targets for these disruptive-type activities.

Throughout this country's history, incidents that disrupted the public peace have figured prominently. The constitutional guarantees allow for ample expression of protest and dissent, and in many cases collide with the preamble's requirement of the government "to ensure domestic tranquility." Typical examples of such conflicting ideology include the protest movements for civil rights in the late 1960s and the Vietnam War protest demonstrations in the early 1970s. The balance between an individual's and group's legitimate expression of dissent and the right of the populace to live in domestic tranquility requires the diligent efforts of everyone to avoid such confrontations in the future.

In modern society, laws have evolved that govern the interaction of its members to peacefully resolve conflict. In the United States, a crowd itself is constitutionally protected under "the right of the people to peacefully assemble." However, assemblies that are not peaceable are not protected, and this is generally the dividing line between crowds and mobs. The laws that deal with disruptive conduct are generally grouped into offenses that disturb the public peace. They range from misdemeanors, such as blocking sidewalks or challenging another to fight, to felonies, such as looting and rioting. Missouri law makes "promoting civil disorder in the first degree" a class C felony, according to Section 574.070 of the Revised Missouri Statutes. As stated in one provision of the law, "Whoever teaches or demonstrates to any other person the use, application, or construction of any firearm, explosive, or incendiary device capable of causing injury or death to any person, knowing or intending that such firearm, explosive or incendiary device be used in furtherance of a civil disorder, is guilty of promoting civil disorder in the first degree."

Types of Crowds[30]

A crowd may be defined as a casual, temporary collection of people without a strong, cohesive relationship. Crowds can be classified into four general categories:

- **Casual Crowd**—A casual crowd is merely a group of people who happen to be in the same place at the same time. Examples of this type include shoppers and sightseers. The likelihood of violent conduct nearly nonexistent.

[29] Historical information in this section is referenced from the Missouri Hazard Mitigation 2010 Update
[30] Haddock, David D. and Polsby, Daniel D. Understanding Riots. Cato Journal, Vol. 14, No. 1

- **Cohesive Crowd**—A cohesive crowd consists of members who are involved in some type of unified behavior. Members of this group are involved in some type of common activity, such as worshiping, dancing, or watching a sporting event. Although they may have intense internal discipline (e.g., rooting for a team), they require substantial provocation to arouse to action.
- **Expressive Crowd**—An expressive crowd is one held together by a common commitment or purpose. Although they may not be formally organized, they are assembled as an expression of common sentiment or frustration. Members wish to be seen as a formidable influence. One of the best examples of this type is a group assembled to protest something.
- **Aggressive Crowd**—An aggressive crowd is made up of individuals who have assembled for a specific purpose. This crowd often has leaders who attempt to arouse the members or motivate them to action. Members are noisy and threatening and will taunt authorities. They tend to be impulsive and highly emotional and require only minimal stimulation to arouse them to violence. Examples of this type of crowd include demonstrations and strikes.

Types of Mobs

A mob can be defined as a large disorderly crowd or throng. Mobs can be emotional, loud, tumultuous, violent, and lawless. Like crowds, mobs have different levels of commitment and can be classified into four categories:

- **Aggressive Mob**—An aggressive mob is one that attacks, riots, and terrorizes. The object of violence may be a person, property, or both. An aggressive mob is distinguished from an aggressive crowd only by lawless activity. Examples of aggressive mobs are the inmate mobs in prisons and jails, mobs that act out their frustrations after political defeat, or violent mobs at political protests or rallies.
- **Escape Mob**—An escape mob is attempting to flee from something such as a fire, bomb, flood, or other catastrophe. Members of escape mobs have lost their capacity to reason and are generally impossible to control. They are characterized by unreasonable terror.
- **Acquisitive Mob**—An acquisitive mob is one motivated by a desire to acquire something. Riots caused by other factors often turn into looting sprees. This mob exploits a lack of control by authorities in safeguarding property. Examples of acquisitive mobs would include the looting in South Central Los Angeles in 1992, or food riots in other countries.
- **Expressive Mob**—An expressive mob is one that expresses fervor or revelry following some sporting event, religious activity, or celebration. Members experience a release of pent up emotions in highly charged situations. Examples of this type of mob include the June 1994 riots in Canada following the Stanley Cup professional hockey championship, European soccer riots, and those occurring after other sporting events in many countries, including the United States.

Although members of mobs have differing levels of commitment, as a group they are far more committed than members of a crowd. As such, a “mob mentality” sets in, which creates a cohesiveness and sense of purpose that is lacking in crowds. Thus, any strategy that causes individual members to contemplate their personal actions will tend to be more effective than treating an entire mob as a single entity.

Historical Statistics

Missouri[31][32][33]

Fortunately, Missouri has not experienced a trend of consistent riotous behavior or disruptive civil disorder, as some other states have witnessed in the past several decades. While far from recent, Missouri's most notable incident is the famous 1954 prison riot in Jefferson City, which stands as the State's worst-case example of a full-scale riot. Other events in Missouri's early history, as well as those from the late 1960s through this decade, indicate the State is not immune to riots, protests, and social upheaval, but no event caused the destruction that occurred during the 1954 prison riot. Some brief examples of Missouri's riotous events are provided below.

In the spring of 1832, citizens in Jackson County began to show their hostility toward Mormon newcomers by stoning their houses. In July 1833, a public meeting to determine the Mormon question resulted in demands that no more Mormons be allowed to settle there, that Mormons already residing in the county move out immediately, and that the Mormon newspaper (the Evening and Morning Star) be suspended. When the Mormon settlers refused these demands, the citizens razed the newspaper office, threw the press in the Missouri River, and tarred and feathered two Mormons. The Mormons appealed their plight to Governor Daniel Dunking, who issued a decision denying any citizen the right to take into his own hands the redress of grievances. He recommended that the Mormons take their case to civil court to uphold their rights. Incensed by this action, about 50 armed men attacked a Mormon settlement called Big Blue near Independence on October 31, 1833, beating several of the men and destroying 10 homes. Hostilities continued the next two nights. On November 4, a band of citizens fought about 30 Mormons at Big Blue; three citizens, including one Mormon, were killed. Feeling they were outnumbered, most of the Mormons left the county as a result. The few who remained eventually left as well due to continued threats and hostilities.

In 1906, on the night before Easter Sunday in Springfield, a mob of 6,000, fueled by alcohol and rumors of a white woman's rape, battered down the jailhouse doors and carried away three black men and hanged them in the town square. Within hours, new rumors spread that black neighborhoods were about to be destroyed. Hundreds of black people fled before the State militia arrived to restore order. In the months that followed, a grand jury indicted more than a dozen people for the hangings, and the story of the woman's attack proved to be untrue. Only one person went to trial, however, and the jury deadlocked without reaching a verdict. In her book about the incident and its aftermath, "Many Thousand Gone," Katherine Lederer notes that until 1906, Springfield had a thriving black population, but the population has never recovered.

On September 22, 1954, a full-scale riot broke out at the Men's State Penitentiary in Jefferson City at about 6:00 p.m., after an inmate released several prisoners. The inmate had obtained keys from a guard by a ruse. At 7:00 p.m., all available state highway patrolmen were directed to report to the penitentiary as quickly as possible to quell the riot. Several buildings and vehicles were burning at that time, and some 500 inmates were loose, hurling bricks, yelling, and attempting to escape. Both chapels were ablaze, as well as several prison shops and factories. Seeing the fires, which were visible at dusk from about 20 miles away, prisoners at the Algoa reformatory and the women's prison staged separate rebellions there. Damage to state property at those facilities was minimal, but at the main prison, only

[31] Missouri Day By Day. Missouri State Library References Department

[32] Missouri Highway Patrol, 50 Years. Missouri State Library, Reference Services Department

[33] Historical information in this section is referenced from the Missouri Hazard Mitigation 2010 Update

cell houses and buildings equipped with sprinklers survived. By 11:30 p.m., 285 patrolmen in 202 cars were on the scene, and by midnight, some 100 St. Louis policemen carrying submachine guns had arrived by special train. They surrounded cell houses B and C—the only halls in which guards were still held hostage. Highway patrolmen and arriving National Guardsmen took positions on rooftops overlooking the quadrangle—a yard between the larger cell houses. From that vantage point, they opened fire, seriously wounding many inmates in the exchange. Shortly after 7:00 a.m. the next day, the last guard taken hostage was released, and the rioters, having no alternative, gave up shortly thereafter. By mid-morning, 2,000 police officers and National Guardsmen were on duty at the prison. When the riot was over, 3 inmates had been killed and 21 wounded by gunfire. One other prisoner was murdered by stabbing and beating, and eight others were injured in fighting with each other. Five buildings were completely destroyed, and two others partially destroyed, resulting in more than $10 million in losses to state property.

On October 23, 1954, another riot occurred at the State Penitentiary while state troopers were still technically operating the institution. This melee was between white and black inmates and started over food. Bricks began to fly, followed by gunfire from the troopers. Approximately 35 prisoners were wounded in that incident.

On the evening of March 19, 1958, at the Algoa Intermediate Reformatory, east of Jefferson City, quick action by then Governor James T. Blair and a contingent of state highway patrolmen with riot guns quelled a potential inmate uprising. The governor himself and the patrolmen entered the facility amid reports of unrest following the resignation of the institution’s acting superintendent. When no trouble occurred, the troopers were removed after about two hours.

On April 9, 1968, the Kansas City Police Department requested the help of the Missouri Highway Patrol in quelling rioting, bombing, and looting in the eastern part of the city in the wake of the assassination of Martin Luther King, Jr. Over 200 officers reported to the staging area at District Four of the State Highway Department to receive their assignments and began patrolling the downtown area. Officers arrested numerous persons for charges ranging from curfew violations to felonious assault. They remained on duty for 10 days until peace was restored.

Twice in May 1969, demonstrations at Lincoln University in Jefferson City resulted in about 200 highway patrolmen being called to the scene to combat arson, sniper fire, and vandalism on campus. The Student Union was burned during those demonstrations.

On February 17, 1975, at Algoa Intermediate Reformatory, a minor riot broke out, resulting in tear gas being thrown into dormitories at the institution. Three prison officials suffered minor injuries, and one inmate required stitches to close a wound. The incident resulted in about $5,000 in property damage.

In December 1977 and January 1978 in Southeast Missouri, farmers making up an American Agricultural Movement staged demonstrations to protest what they felt were unfair prices for their products, as maintained by government price supports. The rallies continued through April 1978 with picketing, tractorcades, and stoppage of highway traffic throughout the area, despite high winds, ice, and snow. More than 300 farm tractors were involved in at least one of these actions. On January 11, highway patrol troopers on Interstate 55 near Hayti arrested seven farmers and charged them with failure to obey a reasonable request, assault, and damaging state property. Four others were arrested on I-55 near Caruthersville for driving their pickup trucks slowly side by side, preventing traffic from passing.

Twenty-five farmers with their tractors were involved in a fracas with 12 officers near Hayti. Two patrol cars were damaged, and one officer sustained minor injuries when shoved by an irate farmer into the path of a road grader.

On April 29, 1992, in Warrensburg, racial tensions mounted following the announcement of the controversial Rodney King verdict. The Johnson County Emergency Operations Center was activated for several hours as police remained on alert status for a potential serious disturbance. Military police from nearby Whitman Air Force Base were also placed on standby alert status, but no major problems occurred.

***United States*[34]**

Incidents of civil disorder that erupted into violence are part of American history, spanning several centuries. In March 1770, just prior to the Revolutionary War, a riot occurred when Boston citizens jeered and taunted British soldiers and began throwing things at them during a demonstration. Five people were killed when the troops fired during the incident, which became known as "The Boston Massacre." Three years later, on December 16, 1773, a group of Boston citizens protested the British tax on tea by throwing it overboard. The "Boston Tea Party" was a harbinger of troubles that eventually led to the Revolutionary War.

On May 4, 1886, another violent event occurred in Haymarket Square in Chicago when a confrontation took place between police and strikers at the McCormick reaper works. A bomb was thrown and a gun battle erupted, during which seven police officers and four workers were killed. Many police and civilians were also injured in what became known as the "Haymarket Square Riot."

Controversy over civil rights and the unpopular war in Vietnam during the 1960s and 1970s resulted in one of the most turbulent periods in American history. During this same time, major riots occurred in Los Angeles (1965); Detroit (1967); Chicago (1968, during the Democratic National Convention); Santa Barbara, California (1970); East Los Angeles (1970 and 1971); and Attica, New York (1971, during a major prison riot). Violent rioting once again erupted across the country on April 29, 1992, when four police officers were acquitted after being accused of beating a black suspect (Rodney King). Also in recent years, issues such as abortion, gay rights, immigration, and gun control have generated great public debate and resulted in many mass assemblies and demonstrations.

Measure of Probability and Severity

Probability: Low

Severity: Low to High

Across the nation, police reports reflect a fairly steady rate of theft, mugging, arson, and homicide incidents. But these criminal acts do not amount to "riots." In their article on "Understanding Riots"[35] published in the *Cato Journal* (Vol. 14, No 1), David D. Haddock and Daniel D. Polsby note that a large crowd itself is not an incipient riot merely because it assembles a great many people. Haddock and Polsby explain that "starting signals" must occur for civil disorder to erupt; these starting signals include certain kinds of high profile events. In fact, incidents can become signals simply because they have been signals in the past. In Detroit, for example, Devils Night (the night before Halloween) has in recent years become a springboard for multiple, independent, and almost simultaneous acts of arson. With any

[34] Historical information in this section is referenced from the Missouri Hazard Mitigation 2010 Update.

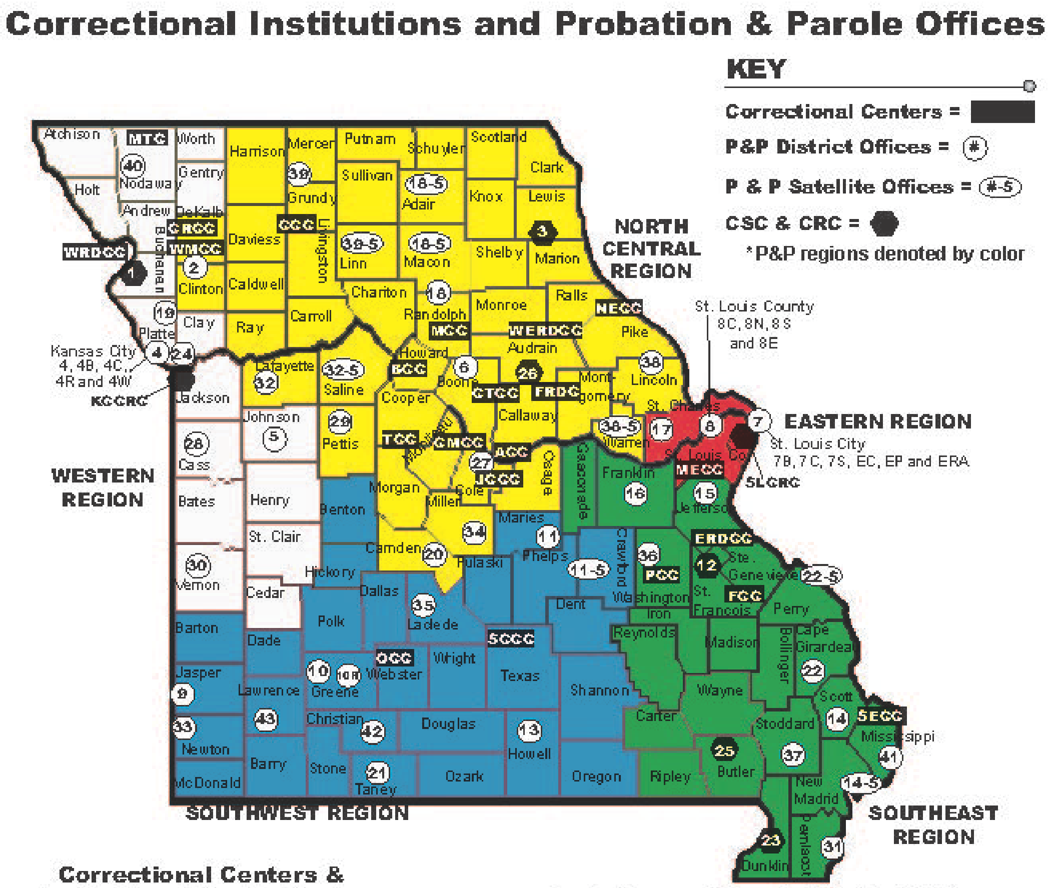
[35] Haddock, David D. and Polsby, Daniel D. Understanding Riots. Cato Journal, Vol. 14, No. 1

conventional triggering event, such as news of an assassination or unpopular jury verdict, crowds form spontaneously in various places as word of the incident spreads, without any one person having to recruit them. But since not every crowd threatens to evolve into a riot, the authors reason that a significant number of people must expect and desire that the crowd will become riotous. In addition, "someone has to serve as a catalyst—a sort of entrepreneur to get things going." A typical action is the breaking of a window (a signal that can be heard by many who do not necessarily see it). Someone will throw the first stone, so to speak, when he calculates the risk of being apprehended has diminished to an acceptable level. This diminished risk is generally based on two variables—the size of the crowd relative to the police force and the probability that others will follow if someone leads. The authors conclude that once someone has taken a risk to get things started, the rioting will begin and spread until civil authorities muster enough force to make rioters believe they face a realistic prospect of arrest.

Nationwide, riots are apt to be a recurrent, if unpredictable, feature of social life. Without question, Missouri will continue to experience future episodes of marches, protests, demonstrations, and gatherings in various cities and communities that could lead to some type of disruptive civil disorder. However, based on the State's general history of civil disturbance and the various human factors noted above, the probability that such incidents will develop into full-scale riots is considered low.

Regarding penal institutions, much has been done in Missouri and other states to alleviate poor living conditions, which are underlying factors in many riots (prison overcrowding, poor treatment of inmates, lack of grievance procedures, etc.). The state has been building new prisons for several years and expanding facilities to create more space and otherwise improve facilities for its inmate population. The number of individuals as of January 2013 was 53,744. The number in institutions was 30,000, and the number on parole was 75,000. One federal prison is located in the State, in Springfield. A map of the correctional institutions and probation and parole offices in the State is provided as Figure 3.3.13.1 also accessible at http://doc.mo.gov/documents/mapinstpp.pdf.

Figure 3.3.13.1 - Correctional Institutions and Probation and Parole Offices



Correctional Centers & Institutional Parole Region

ACC - Algoa Correctional Center, Jefferson City
BCC - Boonville Correctional Center, Boonville
CMCC - Central Missouri Correctional Center, Jefferson City (closed)
CCC - Chillicothe Correctional Center, Chillicothe
CRCC - Crossroads Correctional Center, Cameron
ERDCC - Eastern Reception, Diagnostic & Correctional Center, Bonne Terre
FCC - Farmington Correctional Center, Farmington
FRDC - Fulton Reception & Diagnostic Center, Fulton
CTCC - Cremer Therapeutic Community Center, Fulton
JCCC - Jefferson City Correctional Center, Jefferson City
MTC - Maryville Treatment Center, Maryville
MECC - Missouri Eastern Correctional Center, Pacific
MCC - Moberly Correctional Center, Moberly
NECC - Northeast Correctional Center, Bowling Green
OCC - Ozark Correctional Center, Fordland
PCC - Potosi Correctional Center, Potosi
SCCC - South Central Correctional Center, Licking
SECC - Southeast Correctional Center, Charleston
TCC - Tipton Correctional Center, Tipton
WMCC - Western Missouri Correctional Center, Cameron
WRDCC - Western Reception, Diagnostic & Correctional Center, St. Joseph
WERDCC - Women's Eastern Reception, Diagnostic & Correctional Center, Vandalia

Probation and Parole District Offices

1. St. Joseph Community Supervision Center (CSC)
2. Cameron
3. Hannibal Community Supervision Center (CSC)
4. Kansas City (5 offices)
5. Warrensburg
6. Columbia
7. St. Louis City (6 offices)
8. St. Louis County (4 offices)
9. Joplin
10. Springfield (2 offices)
11. Rolla (Steelville Satellite)
12. Farmington Community Supervision Center (CSC)
13. West Plains
14. Sikeston (New Madrid Satellite)
15. Hillsboro
16. Union
17. St. Charles
18. Moberly (Macon and Kirksville Satellites)
19. Liberty
20. Camdenton
21. Branson
22. Cape Girardeau (Perryville Satellite)
23. Kennett Community Supervision Center (CSC)
24. Independence
25. Poplar Bluff Community Supervision Center (CSC)
26. Fulton Community Supervision Center (CSC)
27. Jefferson City
28. Belton
29. Sedalia
30. Nevada
31. Caruthersville
32. Lexington (Marshall Satellite)
33. Neosho
34. Lake Ozark
35. Lebanon
36. Potosi
37. Dexter
38. Troy (Warrenton Satellite)
39. Trenton (Brookfield Satellite)
40. Maryville
41. Charleston
42. Nixa
43. Aurora

KCCRC: Kansas City Community Release Center (CRC)
SLCRC: St. Louis Community Release Center (CRC)

Source: Missouri Department of Corrections Division of Adult Institutions http://doc.mo.gov/documents/mapinstpp.pdf

Should Missouri experience future incidents of disruptive civil disorder or rioting, the severity of a given event could range from low to high, depending on many factors. A spirited demonstration that gets out of hand may result in several arrests, minor damage to property (police vehicles with broken windows, etc.), some injuries, and manpower/overtime costs for police, fire, and other response services. To a greater extent, the threat of urban or intercity riots has the potential for millions of dollars in property damage, possible loss of life, and serious injuries, and extensive arrests. Sustaining police at the scene for extended periods, and possibly mobilizing state highway patrol and National Guard units, can add to the extensive manpower costs. Still, such riots tend to be confined to a single site or general area of a community rather than multiple locations or several areas of the State at the same time. Once a riot has occurred, police in other cities are generally on standby for possible riotous conditions and are better able to alleviate potential disturbances before they develop into full-scale riots.

Impact of the Hazard

When rioting does break out, it generally proves extremely difficult for first-responder law enforcement authorities to quell the mob promptly. The rules of constitutional law set stringent limits on how police officers can behave toward the people they try to arrest. Restraint also plays a crucial part in avoiding any action that "fans the flames." Initial police presence is often undermined because forces may be staffed below the peak loads needed to bring things back under control. As a result, the riot may continue until enough state police or National Guard units arrive to bolster the arrest process and subsequently restore order. In many cases, damage to life and property may already be extensive.

The information in Table 3.3.13a is from the Impact Analysis of Potential for Detrimental Impacts of Hazards done for the Emergency Management Accreditation Program.

Table 3.3.13a EMAP Impact Analysis: Civil Disorder

Subject	Detrimental Impacts
Health and Safety of Persons in the Area at Time of Incident	Localized impact expected to be severe for unprotected personnel and moderate to light for protected personnel.
Health and Safety of Personnel Responding to the Incident	Localized impact expected to be severe for unprotected personnel and moderate to light for protected personnel.
Continuity of Operations	Damage to facilities/personnel in the area of the incident may require temporary relocation of operations.
Property, Facilities, and Infrastructure	Localized impact to facilities and infrastructure in the area of the incident. Some severe damage possible.
Delivery of Services	Localized disruption of lines of communication and destruction of facilities may postpone delivery of some services.
The Environment	May cause extensive damage in isolated cases and some denial or delays in the use of some areas. Remediation needed.
Economic and Financial Condition	Local economy and finances adversely affected, possibly for an extended period of time, depending on damage.
Regulatory and Contractual Obligations	Regulatory waivers may be needed. Fulfillment of some contracts may be difficult. Impact may reduce deliveries.
Reputation of or Confidence in the Entity	Ability to respond and recover may be questioned and challenged if planning, response, and recovery not timely and effective.

Synopsis

In the wake of numerous urban riots in the late 1960s and beyond, a unique approach in law enforcement began to emerge as a viable means to reduce the risk of such future riots. Known as "community policing," its philosophy rests on the belief that reducing and controlling serious crime requires the police to pay renewed attention to all problems that allow serious crime to occur. In its comprehensive report following the devastating 1967 Detroit riot for example, the Kerner Commission noted that police "cannot, and should not, resist becoming involved in community service matters." The benefits to law enforcement and public order, the commission says, include the following:

- Because of their "front-line position" in dealing with ghetto problems, police will be better able to identify problems in their community that may lead to disorder.
- They will be better able to handle incidents requiring police intervention.
- Willing performance of such work can gain police the respect and support of the community.
- Development of non-adversary contacts can provide the police with a vital source of information and intelligence concerning the communities they serve.

In his paper entitled "Preventing Civil Disturbances: A Community Policing Approach," [36]Michigan State University professor Robert C. Trojanowicz says community policing can reduce the potential for riots beyond simply reducing racial tensions between the police and the black community. The organizational strategy of community policing, he writes, "requires freeing some police officers from the isolation of the patrol car, so they can work directly in the community and enlist them as partners in the process of policing themselves. It addresses the need that everyone in the United States deserves to live in a safe and stable community, free of drugs and violence, and reminds us that "until we are all safe, no one is safe." Four basic ways community policing can help in riot prevention, the author says, are as follows:

- It provides a means of gathering superior intelligence that allows us to identify areas at risk, the level of threat in those areas, and weaknesses and strengths within the community.
- It provides the police with a way to address those weaknesses, which often include crime, violence, drugs, fear of crime, disorder, neighborhood decay, and juveniles at risk.
- It reaches out to law-abiding people in the community and involves them in the police process, serving as the vital link required to enlist their help in actively promoting order and stability.
- It reduces the overall risk to riots by improving the relations between the police and the black community.

A community policing officer (CPO), the author notes, is a full-fledged law enforcement officer who makes arrests but is further challenged to find new ways to address old problems. CPOs act as community advocates for needed neighborhood services (prompt trash pickup, demolition of abandoned buildings, etc.) and serve as community liaison to public and private agencies, Trojanowicz writes. "This can mean linking troubled families to affordable counseling services, linking the homeless to shelter, or tapping local business to provide donated supplies for projects to beautify the area." The initiatives are bounded only by the collective imagination of the CPO and the people in the community and their local needs, the author concludes.

For additional information on vulnerability to civil disorder, see Section 3.5.13.

[36] Trojanowicz, Robert C. Preventing Civil Disturbances, A Community Policing Approach. The National Center for Community Policing. Michigan State University

3.3.14 Cyber Disruption

Description of Hazard

Cyber disruption is an emerging hazard that has gained increasing notoriety as the vulnerability to disruption grows parallel with the dependence for cybernetic systems. An official definition for cyber disruption has not been solidified amongst professionals and can only be described as an interruption or disruption of the normal operations, use and/or function of a cybernetic system.

Disruptions can typically fall into two very general categories; un-intentional disruption and intentional disruption. Un-intentional disruptions are the more common type of disruption as they usually occur when a portion of the system fails. This can look like a typo or mistake in the code used to design the system or a physical failure of hardware or network. Disruption can also be a cascading effect of a failure of other systems supporting the network, i.e. power.

Intentional disruption is typically a directed 'attack' on a cybernetic system to achieve an intended goal, which is usually malicious in intent. These types of disruptions are the most worrisome to governments as they pose the potential to cause irreparable harm to the function and capability of critical systems or supporting systems that are used in daily operations.

The FBI defines this intentional disruption as a threat: "a cyber-threat is any circumstance or event with the potential to adversely impact operations (including mission, functions, image, or reputation), agency assets, or individuals through an information system via unauthorized access, destruction, disclosure, modification of information, and/or denial of service."

Historical Statistics

Though it is an emerging hazard, it has not gone unnoticed. Recognizing the national reliance on cyberspace and the interdependent nature of the Nation's current cyber infrastructure, President Obama commissioned the Cyberspace Policy Review. This report was released on May 29, 2009 and builds on the Comprehensive National Cyber Security Initiative (CNCI). The report calls for the development of a National Cyber Security Incident Response Plan (NCIRP). In 2010, the Department of Homeland Security (DHS) issued the Interim Version in September 2010 of the NCIRP. In November 2011, DHS Secretary Janet Napolitano signed the DHS Blueprint for Cyber Future.

As cyber disruption it is still a very new hazard, the reporting and tracking of disruptive events is difficult. In most cases, it is not required to report an event, and when it is reported most of the information is protected due to the sensitive nature of the systems that were disrupted. However, there currently exist a number of complex databases that track historical cyber disruptions. Each system makes use of its own definitions and tracking methods. As of the release of this plan one database lists that 392,223 cyber-attacks[37] have occurred since November 2010, which was when they started tracking such events.

There have been some notable disruption events that did attain national attention:

[37] http://hackmageddon.com/2012-cyber-attacks-statistics-master-index/

- A recent famous cyber event was during the 2012 election when 2,55238 requests for absentee ballots in Miami-Dade Florida were discovered to be the first officially documented time that an election was attempted to be altered by cyber-attacks.
- In early January of 2013, a series of US bank websites were taken down by denial of service attacks, including Capital One, 5th3rd, and PNC banks[39].
- In May of 2011, Lockheed Martin was attacked but it was detected and as a result 100,000 accounts were locked as a precaution[40].

Over all, it is apparent that cyber disruption attacks vary in sources, type, and target. As such it can be difficult to protect and plan for.

Measure of Probability and Severity

Probability: Moderate to High
Severity: Moderate to High

The State of Missouri categorizes the probability of a cyber-disruption as being high. Every second of every day, there will always exist a possibility for both intentional and un-intentional disruptions. To date, historical events within Missouri have tended to be un-intentional. The number of targets for intentional cyber-attacks would seem at this time to be limited to a couple power plants and government databases. Though they are targets, Missouri is not aware of a current threat against any of the critical facilities or databases. Moving forward, awareness of the growing threat from both domestic and international cyber-attacks does impress the need to develop robust defense and counter attack systems to protect against the increasing likelihood of an attack.

The State of Missouri categorizes the severity of a Cyber Disruption ranging from low to high depending upon the system disrupted and the intention of the attacker. Some systems have redundant capabilities or are not critical to daily operations. As such the severity of a disruption to that system is low. However, there are other systems that are integral to operations, contain sensitive information, or provide access/control to critical systems. A disruption to those systems would have a severe impact on the state.

It is difficult to quantify an exact probability or severity of a disruption due to the limited information available and the many unknown factors. The intent of an intentional disruptor could range from something as minor as leaving a message to a major issue with sensitive data collection or control of a critical facility. The probability of an error or failure is also hard to quantify as most systems are properly update, replaced, and maintained as needed. Usually it is an extenuating circumstance that drives a failure, which cannot be measured.

Impact of the Hazard

Thought a Cyber Disruption can have limited impacts within a system's own operations, it also can have extended cascading affects throughout multiple systems. The system that is disrupted and the source of

[38] http://www.huffingtonpost.com/2013/03/18/florida-cyberattack-election_n_2901969.html
[39] http://hackmageddon.com/2012-cyber-attacks-statistics-master-index/
[40] http://hackmageddon.com/2012-cyber-attacks-statistics-master-index/

the disruption are major factors in the impact. If it is an intentional disruption and the system is critical then the impact has the potential to quite devastating.

Some examples of cyber disruption impacts include:

- Failure of a medical research database: Localized impact with typically limited impacts that can be recovered due to database backups.
- Government intranet failure due to hardware: Though very disrupting, this event usually doesn't have long term impacts.
- Breach of sensitive database for the justice offices: The information could be altered, added to, or publicly shared causing wide-spread long-term impacts.

Utility services remotely accessed and controlled: The attacker could drastically impact not only the government, critical facilities, and public services but also the public itself.

Table 3.3.14a Impact Analysis

Subject	Detrimental Impacts
Health and Safety of Persons in the Area at Time of Incident	Depending upon the system the impacts could be potentially severe.
Health and Safety of Personnel Responding to the Incident	Depending upon the system the impacts could be potentially severe.
Continuity of Operations	Depending upon the system the impacts could be potentially severe.
Property, Facilities, and Infrastructure	Depending upon the system the impacts could be potentially severe.
Delivery of Services	Depending upon the system the impacts could be potentially severe.
The Environment	Depending upon the system the impacts could be potentially severe.
Economic and Financial Condition	Depending upon the system the impacts could be potentially severe.
Regulatory and Contractual Obligations	Depending upon the system the impacts could be potentially severe.
Reputation of or Confidence in the Entity	Depending upon the system the impacts could be potentially severe.

Synopsis

Cyber Disruption is an emerging hazard that has gained an increasing notoriety as the vulnerability to disruption grows parallel with the dependence for cybernetic systems. The State of Missouri is just becoming aware of the many factors involved in cyber disruption and plan to continuously improving its capability to address them.

For additional information on vulnerability to cyber disruption, see Section 3.5.14.

3.3.15 Hazardous Materials Release (Fixed Facility Accidents/ Transportation Accidents)

Description of Hazard

A hazardous material is any substance or material in a quantity or form that may pose a reasonable risk to health, the environment, or property. The category hazardous material includes incidents involving substances such as toxic chemicals, fuels, nuclear wastes and/or products, and other radiological and biological or chemical agents. For the purposes of this analysis, only accidental or incidental releases of hazardous materials from two different kinds of incidents are addressed: fixed facility incidents and transportation-related accidents. In consideration of recent worldwide and national events, incidents involving terrorism or national attacks, which involve hazardous materials of any type, are addressed in Section 3.3.20 Terrorism, Section 3.3.12 Attack, and Section 3.5.19 Special Events.

Generally, with a fixed facility, the hazards are pre-identified, and the facility is required by law to prepare a risk management plan and provide a copy to the local emergency planning committee (LEPC) and local fire departments. Missouri Tier II forms must also be filed with the Missouri Emergency Response Commission (MERC) at the State Emergency Management Agency (SEMA.) For specific site plans, each county LEPC is required by law to maintain a copy of these plans.

The exact location of a hazardous materials accident is not possible to predict. The close proximity of railroads, highways, airports, waterways, pipelines, and industrial facilities to populated areas, schools, and businesses could put a large number of individuals in danger at any time. In addition, essential service facilities, such as police and fire stations, hospitals, nursing homes, and schools near major transportation routes in the State are also at risk from potential hazardous materials transportation incidents.

Federal Highway Administration statistics indicate that 1 of 10 motor vehicles is engaged in the transport of hazardous materials of some type. The U.S. Army Corps of Engineers also indicates that over 9,000 tons of petroleum products and over 200,000 tons of chemicals and related products are shipped annually by river barge via the Missouri River between Omaha and Kansas City.

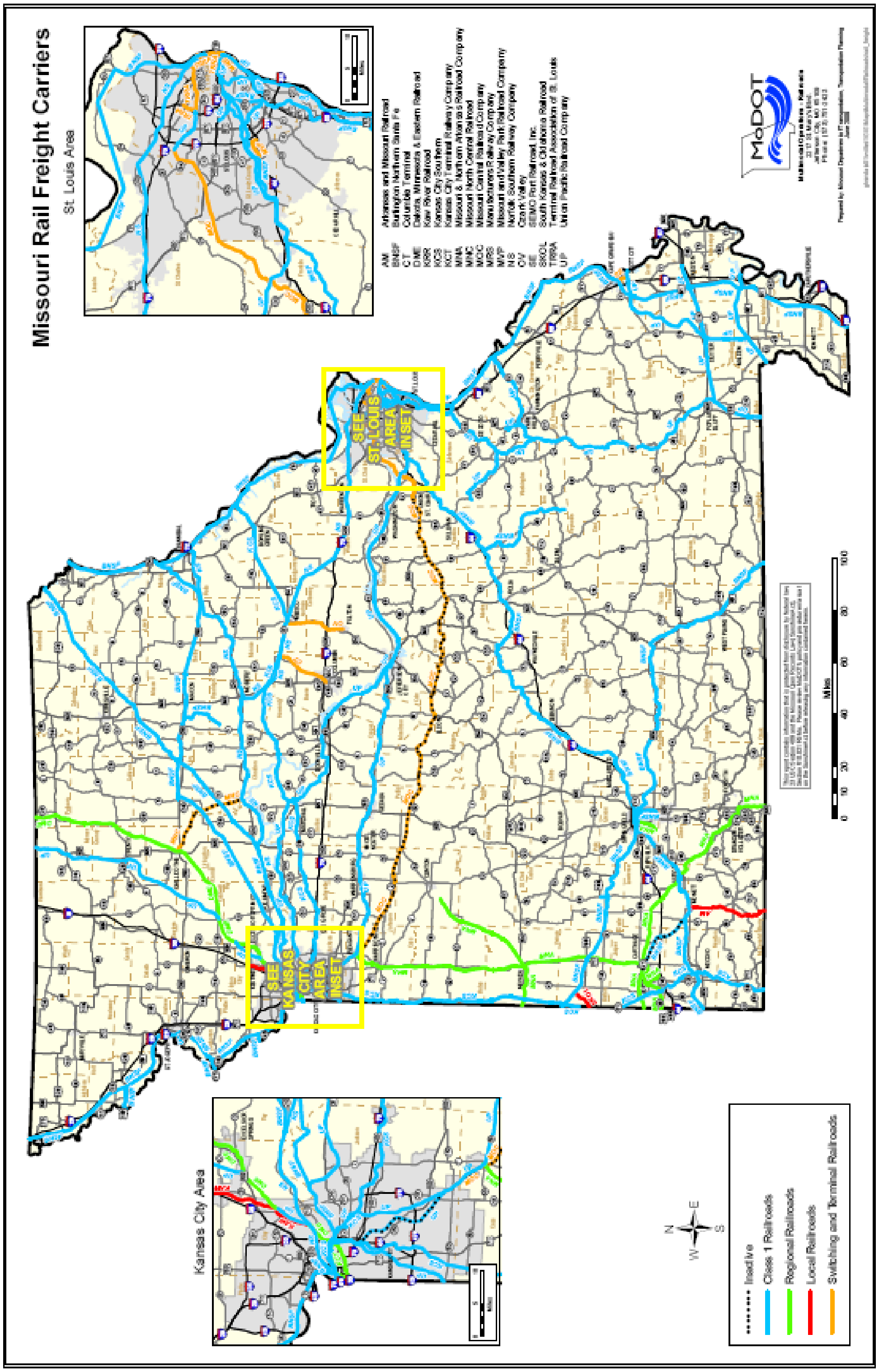
Previous estimates have indicated that, nationwide, over four billion tons of hazardous materials are shipped each year by various transportation modes. Approximately 20 flights each day out of Lambert Airport in St. Louis carry nuclear medicines, and Tri-State Motor Transit Company of Joplin has approximately 25 shipments of high explosives each week.

Missouri is also at risk because of the highway system and geographical location. With Interstate highways such as I-29, I-35, I-44, I-55, I-49, and I-70, Missouri offers premium routes for commercial carriers traversing the continental United States. Even arterial highways in Missouri, such as U.S. Highways 71, 13, 63, 54, and 61 are maintained to provide more favorable traveling conditions than in other central states. Also, the locations of nuclear facilities in relation to mines and fuel processing plants result in shipments of radioactive products and wastes across Missouri.

Missouri is at the crossroads for rail and truck transport of nuclear waste to the Yucca Mountain, Nevada, test site. Truck shipments alone will affect 25 different states, 266 counties, and two Indian reservations. This will be a potentially large waste shipping campaign from as many as 19 nuclear reactors through other corridor states to Nevada.

The railroad systems in Missouri transport voluminous types and amounts of hazardous materials on their 6,351 miles of rails that traverse the State. Though individual cars may be placarded to reveal contents such as hazardous materials, only estimates can be obtained concerning volumes of such materials, because only the interstate traffic is counted or measured. Interstate shipments are accounted for where they originate and terminate.

Figure 3.3.15.1- Missouri Rail Freight Carriers System Map



Source: Missouri Department of Transportation

Increased use and transport of materials across the country has created serious problems for emergency services personnel. Many factors can increase the magnitude of an otherwise simple transportation accident into an incident of potential hazard to high numbers of people. Following are potential factors to be considered:

- Over 14,000 different chemicals are estimated as being shipped by the various transportation modes. Some types of highly toxic chemicals do not require placarding if shipped in quantities of less than 1,000 pounds, even though lesser quantities could devastate a small town.
- Only a few emergency response organizations in the larger cities and counties near the more metropolitan areas have had training for handling peacetime radiological problems. With recent federal grants and programs in place to provide funding for training, exercises, and equipment for state Homeland Security Response Teams and local responders, the general capabilities of hazardous materials response personnel and teams statewide is expected to improve. Refer to Section 3.3.20 Terrorism for more information on this topic.

Other scenarios involve nuclear terrorism and faulty re-entry of nuclear-equipped satellites to earth (such as COSMOS 954 in 1978 and SKYLAB in 1980). However, transport of radioactive materials presents the most probable scenario for a radiological incident. The U.S. Department of Energy is currently shipping radioactive waste by truck to repositories in Texas and Utah. These trucks cross Missouri through St. Louis and Springfield on I-270 and I-44.

The federal government has finalized development of long-term repositories for spent fuel and other high-level radioactive wastes, and for transuranics (known as TRU waste), at Yucca Mountain, Nevada, and Carlsbad, New Mexico, respectively. Speculations have suggested that up to 3,600 shipments per year may go to these facilities, depending on several variables.

A large number of hazardous material shipments come from two corporations in Missouri. Covidian Medical in Maryland Heights (St. Louis County) and Tri-State Motor Transit in Joplin (Jasper County). Covidian Medical is one of the largest manufacturers of radiopharmaceuticals in the world. Tri-State is one of the largest single private carriers of radioactive materials in the world, in addition to transporting all classes of explosive materials and other toxic and hazardous materials.

Missouri is a transportation hub. The interstate corridors of I-44, I-70, I-49, and I-55 are the most commonly used for truck transport. U.S. Highway 36 crosses the northern counties, while U.S. Highway 60 crosses the southern counties. U.S. Highways 71, 13, 65, and 63 are also well-traveled north-south arterial routes.

Although there are railroads throughout Missouri, the Union Pacific route between St. Louis and Kansas City is the most used for large radioactive material shipments. However, the Norfolk Southern from Hannibal to Kansas City has been and is the preferred route for rail transportation of radioactive material. The switching yards at St. Louis and Kansas City process more of these transcontinental trains than any other yards in the country.

During any radiological emergency, regardless of the cause, local officials and emergency responders will likely require state or federal support in the detection, monitoring, and analysis of radiological data for decision-making.

Historical Statistics

The Environmental Protection Agency (EPA) maintains a National Priority List (NPL) which serves primarily informational purposes, identifying for the States and the public those known releases or threatened releases of hazardous substances, pollutants, or contaminants throughout the United States and its territories. The NPL is intended primarily to guide the EPA in determining which sites warrant further investigation. Inclusion of a site on the NPL does not in itself reflect a judgment of the activities of its owner or operator, it does not require those persons to undertake any action, nor does it assign liability to any person. The NPL serves primarily informational purposes, identifying for the States and the public those sites or other releases that appear to warrant remedial actions. In Missouri, there are currently 30 active NPL sites. Those sites are listed in Table 3.3.15a by county.

Table 3.3.15a Missouri Active National Priority List Sites by County

County	Site Name
Cape Girardeau County	Missouri Electric Works
Clay County	Armour Road
	Lee Chemical
Dunklin County	Bee Cee Manufacturing Plant
Franklin County	Oak Grove Village Well
	Riverfront
Greene County	Fullbright Landfill
	Solid State Circuits, Inc
Iron County	Annapolis Lead Mine
Jackson County	Conservation Chemical Company
	Lake City Army Ammunition Plant
Jasper County	Oronogo-Duenweg Mining Belt
Jefferson County	Minker/Stout/Romaine Creek
	Southwest Jefferson County Mining
Lawrence County	Syntex Facility, Inc
Madison County	Madison County Mine
Maries County	Vienna Wells
Newton County	Newton County Mine Tailings Site
	Newton County Wells
	Pools Prairie
Scott County	Quality Plating
St. Charles County	Weldon Spring Former Army Ordnance Works
	Weldon Springs Quarry / Plant/Pits (USDOE)
St. Francois County	Big River Mine Tailings / St. Joe Minerals
St. Louis County	Ellisville Site
	St. Louis Airport/HIS/Futura Coatings

County	Site Name
	Valley Park, TCE
	West Lake Landfill
Washington County	Washington County – Old Mines
	Washington County – Potosi
	Washington County – Richwoods
	Washington County – Lead District – Furnace Creek
Webster County	Compass Plaza Well

Source: United States Environmental Protection Agency, National Priorities List, Superfund Program, http://www.epa.gov/superfund/sites/npl/

Under the Missouri Spill Bill (260.500 – 260.550 RSMo) responsible parties/spillers are required to report releases of hazardous substances to the department's 24-Hour Environmental Emergency Response (EER) Hotline 573-634-2436 or to the National Response Center 800-424-8802. EER Duty Officers maintaining the EER Hotline provide technical assistance regarding the chemical and necessary cleanup actions, work with the responsible party/spiller to ensure that proper cleanup is completed and impact to the public health and environment is minimized, conduct notifications to various agencies, and determine if an on-site response is needed by EER staff. EER Duty Officers complete an EER Incident Report into the Missouri Environmental Emergency Response Tracking System (MEERTS) on each incident reported on the 24-Hour Environmental Emergency Response Hotline or via fax from the National Response Center. Once the EER Incident Report is finalized, it is made available. During the period from 2000-2012, an average annual 3,198 incidents were reported through MEERTS for hazardous substance emergencies/releases.

The EER Section provides a weekly report that summarizes the reported incidents for a given week. This report is available to anyone who requests the report. Please check the website at http://www.dnr.mo.gov/env/esp/meerts.htm for further information.

The EER section also provides the MEERTS database to the public, also available at the website at http://www.dnr.mo.gov/env/esp/meerts.htm. The MEERTS database provides specific details on all reported releases of hazardous substances such as date, county, material released, property use, incident cause, clean-up method and more. Specific information from this database was use to prepare Table 3.3.15b listing railroad/railyard and fixed facility incidents which were reported between 1/1/1993 and 12/14/2012.

Table 3.3.15b **1993-2012 Reported Hazardous Materials Incidents for Selected Incident Types in Missouri**

County	Number of Railroad/ Railyard Incidents	Number of Fixed Facility Incidents*
Adair County	0	15
Andrew County	2	11
Atchison County	1	13
Audrain County	9	44
Barry County	5	60
Barton County	4	13

County	Number of Railroad/ Railyard Incidents	Number of Fixed Facility Incidents*
Bates County	6	13
Benton County	3	23
Bollinger County	0	5
Boone County	4	115
Buchanan County	27	162
Butler County	36	55
Caldwell County	4	12
Callaway County	0	51
Camden County	2	58
Cape Girardeau County	9	108
Carroll County	15	8
Carter County	0	8
Cass County	10	58
Cedar County	0	24
Chariton County	9	16
Christian County	0	34
Clark County	5	3
Clay County	135	169
Clinton County	1	16
Cole County	32	117
Cooper County	2	24
Crawford County	8	43
Dade County	4	7
Dallas County	1	14
Daviess County	3	11
DeKalb County	0	9
Dent County	0	17
Douglas County	0	9
Dunklin County	8	38
Franklin County	27	110
Gasconade County	10	26
Gentry County	0	9
Greene County	56	252
Grundy County	10	16
Harrison County	0	7
Henry County	0	30
Hickory County	0	6
Holt County	2	8
Howard County	1	7

County	Number of Railroad/ Railyard Incidents	Number of Fixed Facility Incidents*
Howell County	7	43
Iron County	11	17
Jackson County	377	695
Jasper County	15	412
Jefferson County	33	298
Johnson County	15	79
Knox County	3	5
Laclede County	2	57
Lafayette County	18	21
Lawrence County	0	45
Lewis County	0	7
Lincoln County	2	32
Linn County	6	9
Livingston County	1	18
Macon County	4	21
Madison County	0	8
Maries County	1	7
Marion County	14	96
McDonald County	1	33
Mercer County	3	4
Miller County	1	40
Mississippi County	2	12
Moniteau County	8	18
Monroe County	12	6
Montgomery County	4	25
Morgan County	0	29
New Madrid County	10	38
Newton County	5	53
Nodaway County	3	21
Oregon County	8	10
Osage County	5	11
Ozark County	0	10
Pemiscot County	4	25
Perry County	9	14
Pettis County	16	88
Phelps County	8	57
Pike County	7	95
Platte County	8	41
Polk County	0	19

County	Number of Railroad/ Railyard Incidents	Number of Fixed Facility Incidents*
Pulaski County	3	75
Putnam County	3	7
Ralls County	5	33
Randolph County	17	30
Ray County	7	22
Reynolds County	0	20
Ripley County	0	5
Saline County	14	24
Schuyler County	0	5
Scotland County	2	4
Scott County	15	73
Shannon County	1	15
Shelby County	2	6
St. Charles County	16	211
St. Clair County	0	13
St. Francois County	15	79
St. Louis County	148	635
St. Louis City*	114	447
Ste. Genevieve County	2	26
Stoddard County	41	39
Stone County	0	19
Sullivan County	1	17
Taney County	3	48
Texas County	1	58
Vernon County	1	49
Warren County	0	43
Washington County	3	99
Wayne County	7	21
Webster County	7	24
Worth County	2	1
Wright County	6	22

Source: Missouri Department of Natural Resources Missouri Environmental Incident Summary Database. * Fixed Facilities means Bulk Chemical Plants, Bulk Petroleum Plants, and Manufacturing Facilities.

The Missouri Department of Natural Resources' role in emergency response is to minimize damages in a hazardous substance emergency, with the highest priority being the protection of people and then the environment.

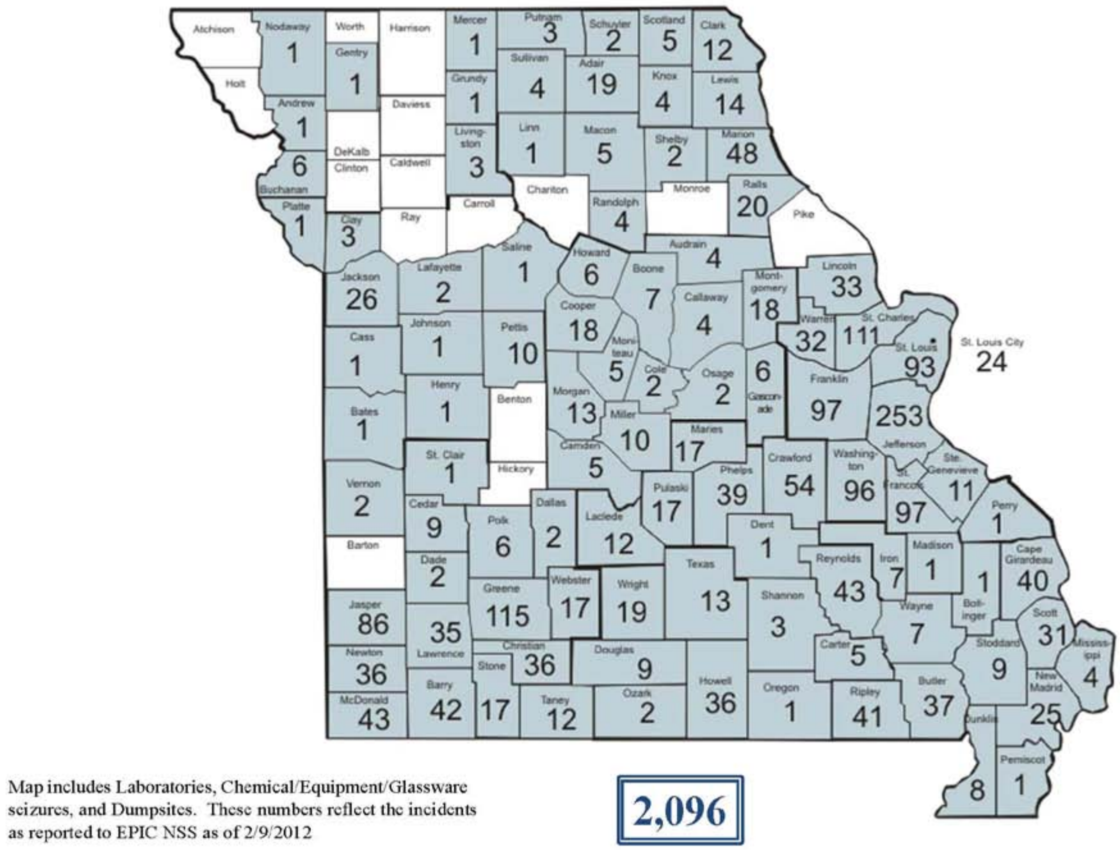
The department's mandate to address environmental emergencies includes "any chemical, petroleum, or other material spilled on to the land, water, or atmosphere" that might impact the public health/safety and/or the environment. The Missouri "Spill Bill"* (Section 260.500 to 260.550 RSMo) requires the department to maintain a 24-hour EER Hotline, and provides the authority to initiate a cleanup or provide cleanup oversight for chemical releases.

The Missouri Highway Patrol's Division of Drug and Crime Control serves as the collection and entry point for statewide methamphetamine laboratory seizures. The data reflected in Figure 3.3.15.2 are cumulative totals of the three types of seizure classifications occurring in each separate county for 2011. The three types of seizures are: operational laboratories, chemical/equipment/glassware and dumpsite seizures. The statistics reflected have been extracted from methamphetamine seizure incidents entered into the National Clandestine Laboratory Seizure System.

The department's involvement in the methamphetamine laboratory crisis in Missouri began in 1997. Law enforcement agencies were being inundated with large quantities of hazardous waste, chemicals and debris associated with the production of methamphetamine. At the direction of the governor, the Missouri Methamphetamine Enforcement and Environmental Protection Task Force was formed to address this and other issues related to the burgeoning problem. Numerous local, state and federal agencies and organizations banded together and, under the direction of the Meth/Special Projects Unit, created the Clandestine Drug Lab Collection Station (CDLCS) Program. Local fire service and law enforcement agencies operate collection stations throughout the State with technical and financial assistance provided by the department.

The Meth/Special Projects Unit provides a variety of supplies, personal protective equipment and air monitoring equipment to law enforcement at no cost. Examples of packaging/cleanup supplies available include 5-gallon chemical overpack buckets, hazardous materials labels, eye wash bottles, safety goggles, safety glasses, absorbent material, pH paper, hand sanitizer, etc. Personal protective equipment includes chemical protective coveralls, boot covers, nitrile gloves, air-purifying respirators, cartridges, self-contained breathing apparatus and air cylinders. Drager pumps and tubes along with organic vapor meters and multi-gas meters have been provided to collection station operators, drug task forces and law enforcement agencies throughout the State. Inquiries concerning supplies and equipment procurement may be made by e-mail or by calling 573-526-3349. Information about the Meth/Special Projects Unit can be found at http://www.dnr.mo.gov/env/esp/meth-special-projects.htm

Figure 3.3.15.2- Missouri Methamphetamine Laboratory Incidents 2011



Source: Missouri Highway Patrol, Methamphetamine Statistics, http://www.mshp.dps.missouri.gov/MSHPWeb/Publications/Reports/2011StatewideLabIncidents.pdf

Measure of Probability and Severity

Fixed Facility Accidents

Probability: Moderate
Severity: Moderate

Transportation Accidents

Probability: High
Severity: Moderate
Note: While there have been more documented fixed facility accidents, the probability is ranked greater for transportation accidents due to the potential for more incidents to occur, but inability to predict exactly where these incidents will occur. The severity to the environment will vary in every case depending on the amount spilled or releases, the type of chemical, method of release, location of release, time of day, and weather conditions. Close coordination between the Missouri Department of Natural Resources, the U.S. Environmental Protection Agency (EPA), the local jurisdiction, and the spiller (responsible party) is required to ensure that potential impacts to public health and the environment are adequately addressed.

Hazardous Materials Fixed-Facility Accident

The probability of occurrence is rated as moderate. With the new regulations from EPA and the Occupational Health and Safety Administration, along with more stringent state laws and employee awareness training, this rating may be lowered to low or raised to high based on past performance. This rating means the probability of occurrence is possible during the expected lifetime of the facility.

The severity of consequences is rated as moderate but may be either low or high depending on the type and amount of chemical released. This means the chemical is expected to move into the surrounding environment at a concentration sufficient to cause serious injuries and/or death, unless prompt and effective corrective actions are taken. Injuries and/or death would be expected only for personnel exposed over an extended period or when individual personal health conditions create complications.

Hazardous Materials Transportation Accident

The probability of occurrence is rated as high because of the large volume of hazardous materials being hauled over the highways and railways in Missouri. This rating means that the probability of occurrence is considered sufficiently high as to assume that an event will occur at least once within any mode of transportation (including water, pipeline, and air) during a three-year HSEES reporting period.

The severity of the consequences is rated as moderate, but may be either low or high depending on the location of the accident and the time of day. This rating means injuries and/or death are expected only for exposed personnel over extended periods of time or when individual personal health conditions create complications.

Impact of the Hazard

The entire State of Missouri is susceptible to this type of hazard, depending on a number of factors such as the type of chemical, amount released/spilled, method of release, location of release, time of day, and weather conditions.

This hazard could have a significant impact on the public health, the environment, private property, and the economy. The impact of this type of disaster will likely be localized to the immediate area surrounding the incident. The initial concern will be for people, then the environment. If contamination occurs, the spiller is responsible for the cleanup actions and will work closely with the Missouri Department of Natural Resources, EPA, and the local jurisdiction to ensure that cleanup is done safely and in accordance with federal and state laws.

Local government (county or municipal) is more often directly impacted by hazardous materials incidents than state or federal government. Local responders are generally the first on scene for any incident. Therefore, they have the responsibility for treating any injured victims and transporting them to a hospital for more complete medical care. Also, local first responders have the initial responsibility for controlling exposure of emergency workers and the public to any radioactive materials and to contain the spread of radioactive contamination as much as possible. While cleanup of any actual spill of radioactive materials rests with the shipper (in most cases), local responders may be required to provide site control for several hours until the responsible parties arrive on the scene.

The information below is from the Impact Analysis of Potential for Detrimental Impacts of Hazards done for the Emergency Management Accreditation Program.

Table 3.3.15c EMAP Impact Analysis: Hazardous Materials

Subject	Detrimental Impacts
Health and Safety of Persons in the Area at Time of Incident	Localized impact expected to be severe for plume area and moderate to light for other adversely affected areas.
Health and Safety of Personnel Responding to the Incident	Adverse impact expected to be severe for unprotected personnel and moderate to light for protected personnel.
Continuity of Operations	Damage to facilities/personnel in the area of the incident may require temporary relocation of some operations.
Property, Facilities, and Infrastructure	Localized impact to facilities and infrastructure in the plume area of the incident, possibly for extended period.
Delivery of Services	Localized disruption of roads and/or utilities may postpone delivery of some services.
The Environment	Localized impact expected to be severe for plume area. Remediation required.
Economic and Financial Condition	Local economy and finances adversely affected, possibly for an extended period of time, depending on damage, extent of cleanup, and length of investigation.
Regulatory and Contractual Obligations	Regulatory requirements must be fulfilled. Fulfillment of some contracts may be difficult. Impact may reduce deliveries.
Reputation of or Confidence in the Entity	Localized impact expected to primarily adversely affect HazMat source owner and local entities.

Synopsis

Any disaster or emergency incident, such as an earthquake or a flood, could result in additional concerns when it involves hazardous materials. For example, during the floods of 1993, a large propane tank farm in St. Louis was threatened by rising floodwaters, forcing evacuations of nearby residents in several areas. Another hazardous materials incident related to the 1993 floods involved an on-going ammonia release from the La Roche Industries, Inc., facility near Crystal City, Missouri, caused by power failure and failure of the cooling system on a large ammonia tank, which ultimately resulted in off-gassing of ammonia through the tank's pressure relief check valves. The ammonia cloud over the plant led to a declaration of restricted air space in the plant vicinity for several days.

In addition, thousands of chemical containers ranging from household products and 55-gallon drums to 10,000-gallon fuel storage tanks were displaced statewide as a result of the flood damage. A federal disaster declaration was issued, the Federal Response Plan (FRP) was implemented, and Emergency Support Function #10—Hazardous Materials Annex was activated to support the statewide response to hazardous materials incidents like these and others that resulted from the flooding.

Each emergency event will need to be evaluated on an incident-specific basis, and top priority must be given to the protection of the public, then the environment, and property.

Tier II Forms are filed and maintained by the Missouri Emergency Response Commission at SEMA. Site-specific plans are on file with each county's local emergency planning commission. Transportation and evacuation routes are addressed in each county emergency operations plan. See Section 3.3.21 Utilities for the natural gas pipeline map. The SEMA Homeland Security Response Teams Map, included in Section 3.3.20 Terrorism, indicates 28 existing or proposed Homeland Security Response Teams for

Missouri. A few of these teams include hazardous materials response teams with enhanced capabilities for response to weapons of mass destruction incidents, including incidents involving nuclear or radiological materials, biological agents, and chemical agents. The SEMA Terrorism Program should be contacted to determine the capabilities of these Homeland Security Response Teams in specific areas.

For additional information on vulnerability to hazardous materials, see Section 3.5.15.

3.3.16 Mass Transportation Accident

Description of Hazard

For the purpose of this plan, mass transportation is defined as the means, or system, that transfers large groups of individuals from one place to another. This profile addresses only transportation accidents involving people, not materials. Thus, mass transportation accidents include public airlines, railroad passenger cars, metro rail travel, tour buses, city bus lines, school buses, riverboat casinos, and other means of public transportation. Commercial motor vehicles are defined as trucks having six or more tires on the power unit, buses or school buses having occupant capacities of 16 or more, and vehicles displaying hazardous materials placards.

Missouri serves as a transportation crossroad for the United States. Missouri, being centrally located in the nation, is a natural hub for many major airlines (approximately 10 airports in the State carry passengers) and other types of tourist and business travel (FAA, 2012). Many cross-country travelers use Missouri terminals to connect with transport changes. The state's airways, railways, and highways are used as nonstop thoroughfares as well.

In 1993, Missouri's largest city, St. Louis, began operating a multi-modal transportation system. Metro Transit operates the MetroBus, MetroLink, and Metro Call-A-Ride system. Overall, the system had approximately 24,087,739 Passenger Boardings for Fiscal Year 2013 six months ending December 31, 2012. The transit system covers more than 574 square miles which includes the City of St. Louis and St. Louis County in Missouri, and the Illinois Counties of St. Clair and Monroe. MetroBus is the largest component of the multi-modal system, operating a fleet of more than 370 vehicles. Six months ending December 31, 2012, MetroBus' Average Weekday Ridership was 96,614 for FY 2013. MetroLink operates 87 Light Rail Vehicles which service 37 stations. Over the course of six months ending December 31, 2012, MetroLink's Average Weekday Ridership was 53,983 for Fiscal Year 2013. Metro Call-A-Ride recently celebrated 25 Years of Service to the Community in 2012. The curb-to-curb paratransit van service operates 121 vehicles. Metro Call-A-Ride's Average Weekday Ridership was more than 2,000 for Fiscal Year 2013 six months ending December 31, 2012.

Normally, the largest numbers of people are transported during the morning and evening rush hours.

Amtrak, the State's major passenger rail carrier, uses tracks that cross the entire state from east to west. Although Amtrak has experienced a decline in passengers during this decade, it continues to carry a large number of passengers daily. The peak periods are related to holidays or special events.

In the early 1990s, construction began on the transformation of U.S. 71 to I-49 along the western edge of Missouri south of Kansas City. The update consisted of upgrading 180 miles of road to interstate highway standards, with new interchanges, overpasses and outer roads. Missouri is also working with Louisiana and Arkansas to link I-49 and I-29. This interstate corridor will link the Gulf Coast ports of New Orleans with south-central Canada.

Branson, Missouri, which is located close to the State's southwestern border, has become one of the State's major tourist attractions. It ranks high among the nation's top attractions. Because Branson is a small community, tourists are more visible there than in Kansas City and St. Louis. The city has been expanding its services (number of hospital beds, fire equipment, and ambulances) and is able to provide more assistance than other small communities in the State.

Tour bus travel in the State is on the increase. With Branson continuing to expand, more bus traffic can be expected. The Passenger Carrier Inspection Division of the Missouri Department of Transportation has developed a comprehensive passenger carrier safety inspection program. Passenger carrier safety is a primary concern for the division because Missouri, and especially Branson, is among the top tourist destinations in North America. Division inspectors conduct safety inspections at destinations or carrier terminals when buses do not have passengers on board.

The division has two classifications of passenger carriers: for-hire and private. For-hire passenger carriers provide service to the general public and are required to register with the division. Private carriers provide passenger service in furtherance of a commercial enterprise. Examples include, but are not limited to, hotel courtesy buses, airport passenger shuttle services, buses operated by professional musicians, and buses for civic and other groups such as scout groups where no fees are collected.

The definition of a passenger carrier varies somewhat depending on whether the operation is entirely intrastate or interstate. The Federal Highway Administration's Office of Motor Carriers defines interstate passenger carrier as any vehicle designed to transport more than eight passengers, including the driver, across state boundaries. The administration defines an intrastate passenger carrier as any vehicle (not operated as a taxi or otherwise exempt) designed to transport more than six passengers, including the driver, within the State.

Historical Statistics

Commercial Vehicles

Commercial motor vehicles have been involved in a significant number of Missouri traffic accidents. Statistics from the Missouri State Highway Patrol Statistical Analysis Center show that in 2011, 9.2 percent of all traffic accidents involved a commercial motor vehicle, compared to 8 percent in 2007.Of fatal traffic accidents, 15.2 percent involved a commercial motor vehicle, decreasing from 16 percent in 2007. A total of 120 persons were killed and 3,479were injured in commercial motor vehicle-related accidents in 2011. In 2007, 168 persons were killed and 5,284 injured in commercial motor vehicle-related accidents. In 2011, accidents involving buses and school buses resulted in four fatalities, compared to six fatalities in 2007.

April 2011, national statistics for transit passengers and motor vehicle occupants were reported; these are summarized in Table 3.3.16a below. National motor vehicle fatality and passenger mile data are from the American Public Transportation Association (APTA), April 2011.

Table 3.3.16a Fatality Rates by Mode of Travel, 2003 – 2008 (Average Deaths per 100 Million Passenger Miles) Highway Vehicle Occupants and Transit Passengers

Type of Vehicle	Death Rate
Highway Vehicles	1.42
Commuter rail	0.06
Rail transit	0.02
Amtrak	0.03
Bus	0.05

Source: American Public Transportation Association, National Transit Database, Federal Transit Administration.

Airlines

Information from the Federal Aviation Administration regarding primary, non-primary commercial service and general aviation airports found at http://www.faa.gov/airports/planning_capacity/passenger_allcargo_stats/passenger/ shows that there are 28 airports in Missouri that carry passengers. Of these, the top ten are listed below including the number of enplanements for each for calendar year 2011 in Table 3.3.16b.

Table 3.3.16b Top Ten Airports by Number of Enplanements for Calendar Year 2011, including Number of Fatalities and Injuries for the Period of 2008-2011.

Airport	County	2011 Enplanements	Fatalities	Injuries
Lambert St. Louis International	St. Louis	6,159,090	0	0
Kansas City International	Platte	5,011,000	0	2
Springfield – Branson National	Greene	349,091	0	0
Branson	Taney	102,093	0	0
Columbia Regional	Boone	40,990	0	0
Joplin Regional	Jasper	27,379	0	0
Waynesville-St. Robert Regional Forney Field	Pulaski	6,978	0	0
Cape Girardeau Regional	Scott	5,940	0	0
Kirksville Regional	Adair	5,100	0	0
Charles B. Wheeler Downtown	Miller	2,121	0	0

Source: Federal Aviation Administration, http://www.faa.gov/airports/planning_capacity/passenger_allcargo_stats/passenger/ and the Federal Aviation Administration Incident Data System (AIDS) http://www.asias.faa.gov/pls/apex/f?p=100:2:0::NO

Railroads

On May 14, 1997, about 9:00 p.m., a Missouri and Northern Arkansas Railroad (M&NA) train, the Cotter North local, was traveling northbound in non-signaled territory when it entered a siding track and collided with an unattended and unoccupied Branson Scenic Railway (BSR) excursion train. The collision occurred in downtown Branson, Missouri, on the M&NA Aurora Subdivision at milepost (MP) 447.3. When the collision occurred, the lead locomotive unit of the striking train derailed and caught fire. Also, both locomotive units of the parked train derailed. Both train crewmembers of the M&NA train sustained minor injuries. The costs associated with the accident were $410,625.

Measure of Probability and Severity for Mass Transportation Accidents

Probability: Moderate

Severity: Moderate

A major accident can occur at any time, even though all safety precautions are in place. Based on the latest available information, the probability and severity of a mass transportation accident are both rated as moderate.

Impact of the Hazard

A mass transportation accident, which could include those involving buses, could burden a local jurisdiction's available medical services. To minimize this problem, mutual aid agreements with

adjoining jurisdictions should be developed between ambulance services and the hospitals. This type of hazard could involve hazardous materials or a fire, which would compound the impacts of the incident. Severe weather could also hamper response efforts.

The information in Table 3.3.16c is from the Impact Analysis of Potential for Detrimental Impacts of Hazards done for the Emergency Management Accreditation Program.

Table 3.3.16c EMAP Impact Analysis: Mass Transportation Accident

Subject	Detrimental Impacts
Health and Safety of Persons in the Area at Time of Incident	Localized impact expected to be severe for incident area and moderate to light for other adversely affected areas.
Health and Safety of Personnel Responding to the Incident	Adverse impact expected to be moderate to light for trained, equipped, and protected personnel.
Continuity of Operations	Damage to facilities/personnel in the area of the incident may require temporary relocation of some operations.
Property, Facilities, and Infrastructure	Localized impact to facilities and infrastructure in the area of the incident. Some severe damage possible.
Delivery of Services	Localized disruption of roads and/or utilities caused by incident may postpone delivery of some services.
The Environment	Localized impact expected to be severe for incident areas and moderate to light for other areas affected by smoke or HazMat remediation.
Economic and Financial Condition	Local economy and finances may be adversely affected, depending on damage and length of investigation.
Regulatory and Contractual Obligations	Regulatory waivers may be needed locally. Fulfillment of some contracts may be difficult. Impact may temporarily reduce deliveries.
Reputation of or Confidence in the Entity	Ability to respond and recover may be questioned and challenged if planning, response, and recovery not timely and effective.

Synopsis

Missouri serves as transportation crossroads for the United States. Branson, Missouri, which is located close to the State's southwestern border, has become a major tourist attraction. Because Branson is a small community, tourists represent a large portion of the population. To meet the needs posed by the large number of tourists, the city has been expanding its services (number of hospital beds, fire equipment, ambulances, etc.) and is able to provide more assistance than other communities of its size. A mass transportation accident could burden a local jurisdiction's available medical services. To minimize this problem, mutual aid agreements should be developed between ambulance services and hospitals of adjoining jurisdictions. The risk of this type of incident is moderate.

Please refer to Missouri Highway Patrol's Missouri Traffic Safety Compendium (573-751-9000 x2299) or access it here. For additional information on vulnerability to mass transportation accidents, see Section 3.5.16.

3.3.17 Nuclear Power Plants (Emergencies and Accidents)

Description of Hazard

There are presently four fixed nuclear facilities or reactors that, under extreme circumstances and conditions, could pose a threat to citizens of Missouri. These four reactors fall into two categories: research reactors and commercial nuclear power reactors. The first category, research reactors, represents a hazard only to personnel or others on-site at the facility. Therefore, these reactors are not included in state radiological plans involving off-site emergency preparedness. For the second category, commercial nuclear power reactors, a worst-case scenario involving a significant release of radioactive material could force the evacuation of the general population within a 10-mile radius of the facility. A release of this magnitude could also contaminate food and water sources within a 50-mile radius.

The magnitude of releases from nuclear plant sites varies depending on the nature of the accident type, reactor design, and meteorological conditions during the release. The Nuclear Regulatory Commission and FEMA have developed regulatory guidance that both the State and utility must meet to protect the health and safety of the general population within the 10-mile Emergency Planning Zone (EPZ). Four classes of emergency action levels are used for early notification of incidents, with clear instructions for emergency organizations within the EPZ. The four emergency classifications listed in progression of severity are notification of unusual event, alert, site area emergency, and general emergency. These levels are discussed below.

- **Notification of Unusual Event**—This classification describes unusual events that are in process or have occurred and indicates a potential degradation of the safety level of the plant. No releases of radioactive material requiring off-site response or monitoring are expected unless safety systems are further degraded.
- **Alert**—This classification describes unusual events that are in process or have occurred and indicate a potential degradation of the level of plant safety. Any releases are expected to be limited to small fractions of the U.S. Environmental Protection Agency (EPA) Protective Action Guideline (PAG) exposure levels.
- **Site Area Emergency**—This classification level describes events in process or having occurred that involve actual or likely major failures of the plant functions needed to protect the public. No releases are expected to exceed EPA PAG exposure levels except near the site boundary.
- **General Emergency**—This classification describes an event in process or having occurred that involves actual or imminent substantial core degradation or melting, with the potential for loss of containment integrity. Releases can reasonably be expected to exceed the EPA PAG exposure levels off-site for more than the immediate site area.

Historical Statistics

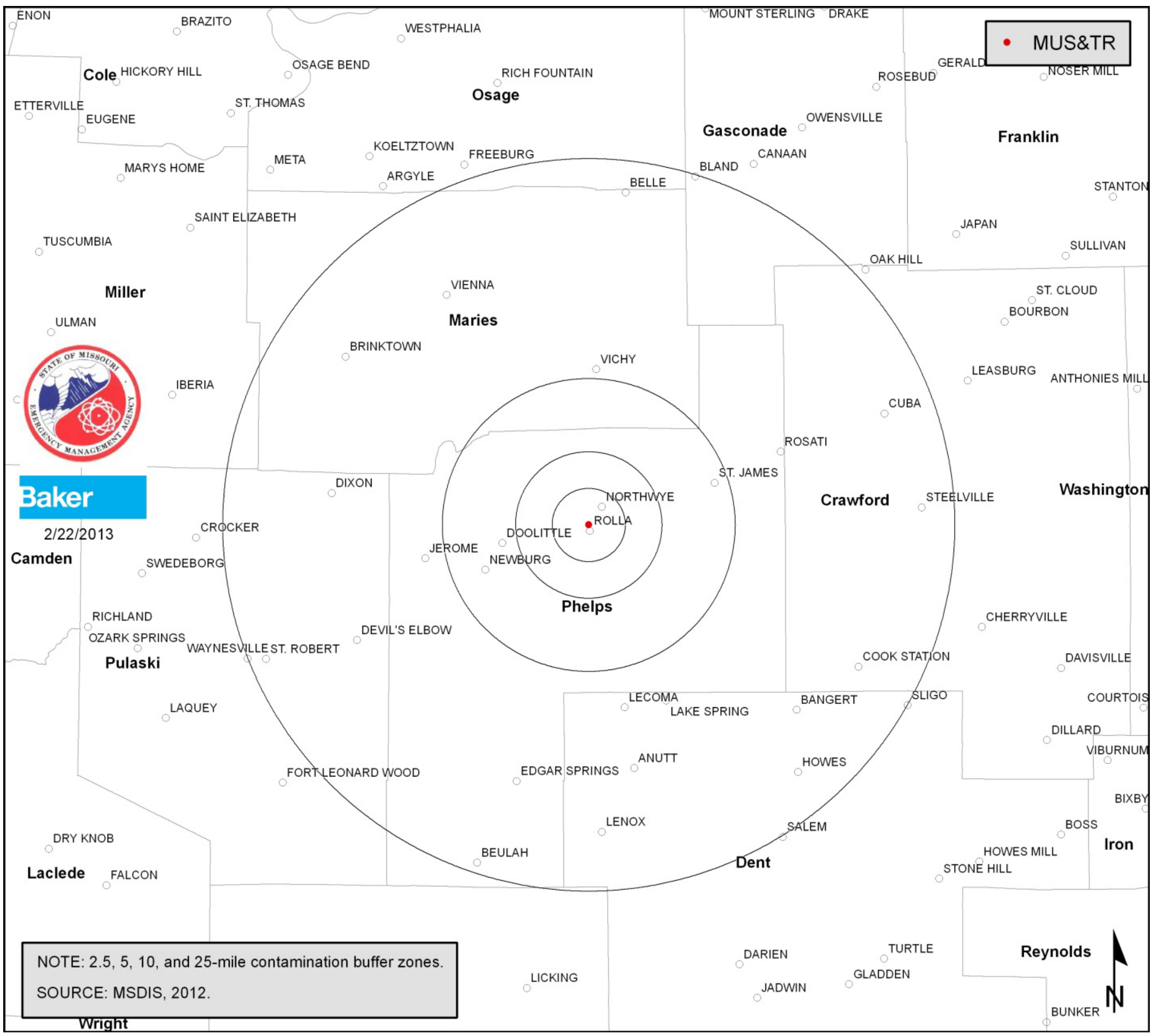
Research Reactors

Two research reactors are located in Missouri: the Missouri University of Science and Technology (MU S&TR) and the University of Missouri–Columbia Research Reactor (MURR). The maximum hypothetical accident from either research reactor would place at risk only personnel working at the facilities or the public within the site boundary of the respective facilities. Both research reactors have emergency plans approved by the Nuclear Regulatory Commission (NRC) that conform with regulatory requirements in 10 CFR 50, Appendix E, and follow the guidance provided by Revision I to NRC Regulatory Guide 2.6,

Emergency Planning for Research and Test Reactors, March 1982, and ANSI/ANS-15.16, Emergency Planning for Research and Test Research Reactors, November 29, 1981.

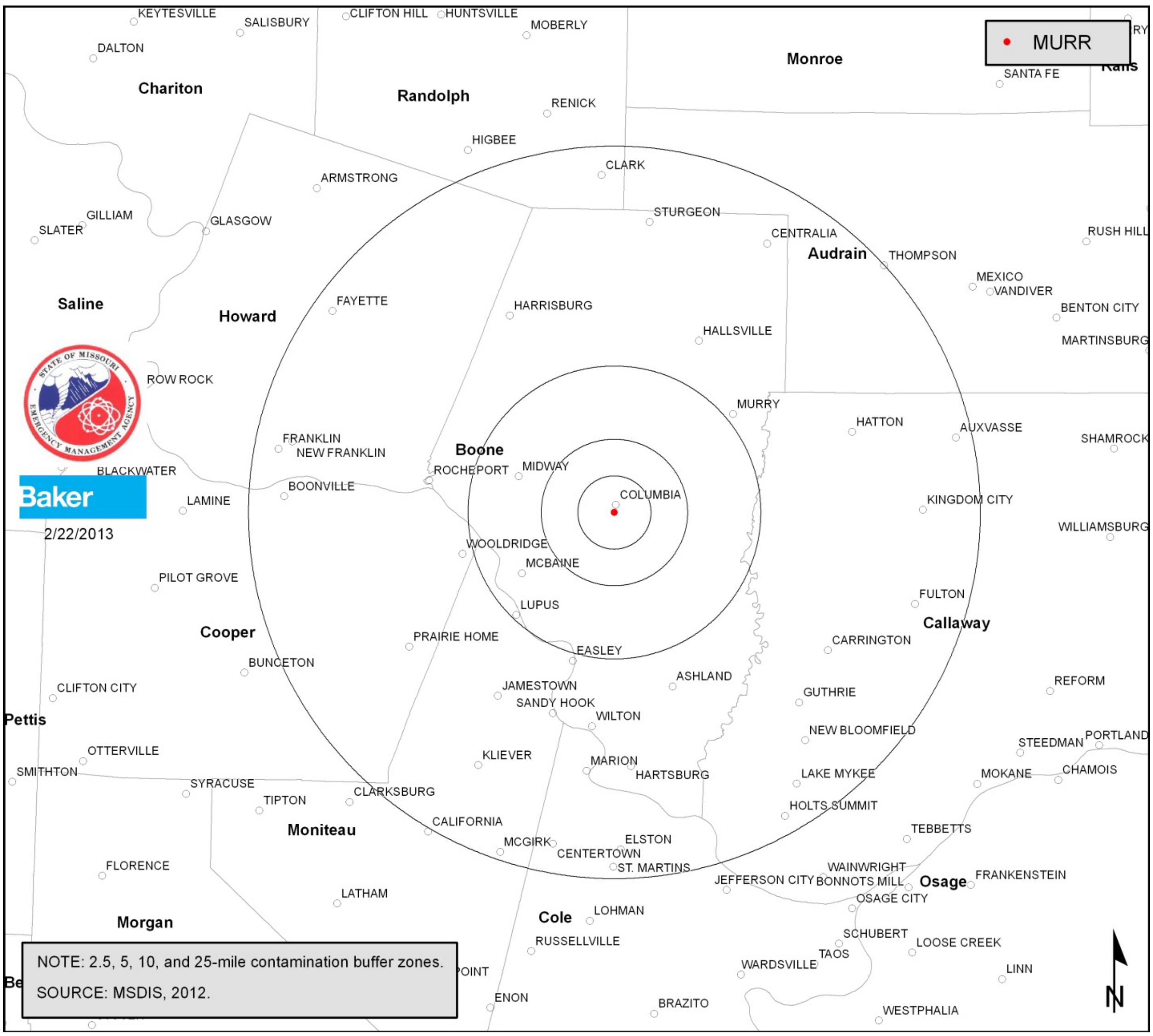
The MU S&TR is a water-moderated pool-type reactor licensed to operate at 200 kilowatts. The MU S&TR is used for training and research purposes. Because the reactor is mainly used for training, it is not operated for long periods of time. The reactor is located on the east side of the Rolla campus near 14th Street and Pine Street in Rolla, Missouri. Due to the low power of licensing (200 kilowatts), prevailing standards and guidelines do not require the establishment of an emergency planning zone. Therefore, no classification higher than a “site area emergency” has been included in the MU S&TR emergency plans. The MU S&TR has been in operation since December 1961 and has never had an incident that would be considered an emergency action level.

Figure 3.3.17.1- Contamination Buffer Zones for MU S&TR



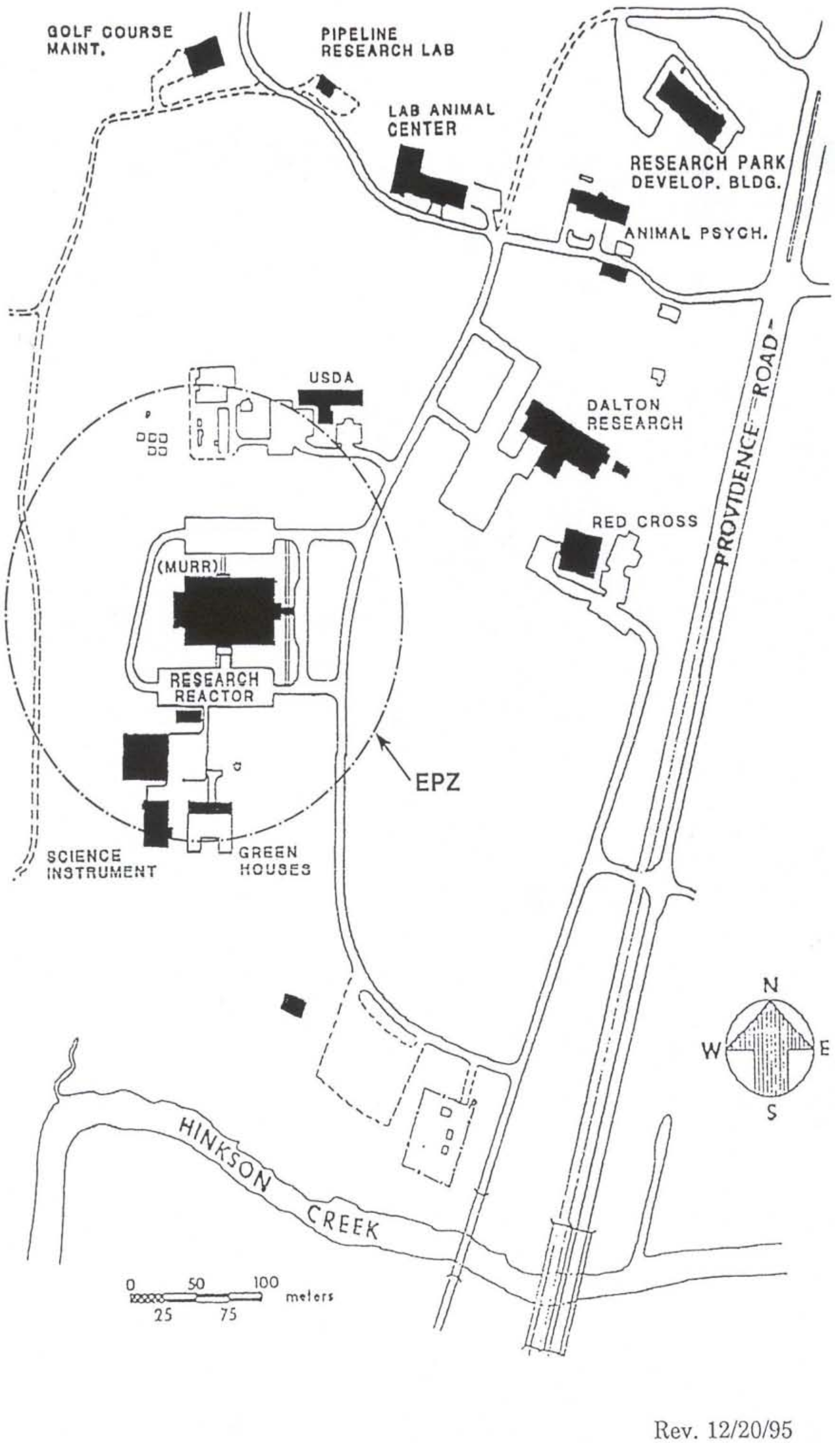
The MURR is a 10 megawatts pressurized water-moderated pool-type reactor with a containment building. The MURR is used to provide research, training, and services to the four campuses of the University of Missouri system as well as other universities, government agencies, and private industry. The reactor is located on a 550-acre tract of land south of the University of Missouri–Columbia campus on Providence Road. The MURR has an emergency planning zone encompassing the area within a 100-meter radius from the exhaust stack (see Figure 3.3.17.2). No credible potential accidents have been identified for the MURR facility that would result in exceeding the classification of "notification of unusual events." As a result, no classification higher than a "site area emergency" is included in the emergency plan for the MURR.

Figure 3.3.17.2 - Contamination Buffer Zones for MURR



The MURR has been in operation since October 1967. The reactor averages 8,060 hours of operation per year (155 hours per week) at peak flux due to the service work that it performs. During its history of operation, the MURR has never had an incident that would be considered an emergency action level.

Figure 3.3.17.3 - Emergency Planning Zone for MURR



Source: State Hazard Analysis, December 2012

Commercial Nuclear Power Reactors

Two commercial nuclear power reactors could have an impact on the health and safety of Missouri citizens. These reactors are the Callaway Nuclear Plant and the Cooper Nuclear Station, both of which are used for electrical power generation. Both utilities have emergency plans that conform to NUREG-0654, FEMA-REP-1 Rev.1, Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants. The utilities and the State are required to demonstrate annually various elements of preparedness through radiological emergency drills evaluated by inspectors representing FEMA and the NRC.

The **Callaway Plant** consists of one unit with a pressurized water reactor capable of providing 1360 megawatts of electricity. The plant is located in Callaway County, Missouri, and is owned and operated by Ameren Missouri, St. Louis. It is located 10 miles southwest of Fulton, 25 miles northeast of Jefferson City, 5 miles north of the Missouri River, and 80 miles west of St. Louis. The population within the 2.5-mile radius of the plant is low (approximately 90 residents). Approximately 8,000 people reside within a 10-mile radius of the plant. The plume exposure pathway has been expanded beyond the 10-mile radius to include the City of Fulton (population 12,000). Thus, the population within the plume exposure pathway is approximately 20,000. The plant site consists of 7,200 acres of land at the site, 6,800 of which are administered by the Missouri Department of Conservation as the Reform Conservation Area. Under this program, part of the area continues to be farmed, with income from farming providing funds for wildlife management and public recreation activities. Land within a 5-mile radius of the plant site is rural, consisting of 60 percent forest, 20 percent farm/crop land, and 20 percent pasture. Figure 3.3.17.4 illustrates the emergency planning zone for the Callaway Nuclear Power Plant. The plant began operating in December 1984 and cost approximately $3 Billion to build. More than 1,000 employees and contractors work at the plant with a total annual payroll of approximately $100 million. The NRC granted a 40-year operating license, which is the customary license for nuclear plants. However, the plant received a 20-year extension to operate. Callaway Plant has filed for a 20-year extension in 2011, which should decision by the end of 2013[41]. If approved, the plant could operate until 2044.

[41] http://www.nrc.gov/reactors/operating/licensing/renewal/applications/callaway.html

Figure 3.3.17.4 - Emergency Planning Zone for Callaway Nuclear Power Plant

Source: State Hazard Analysis, December 2012

The **Cooper** Nuclear Station is a direct-cycle boiling water-type reactor with a net electrical generating capacity of 800,000 kilowatts. The facility is owned by the Nebraska Public Power District of Columbus, Nebraska. The plant is located on the Nebraska side of the Missouri River in Brownville, Nebraska, approximately seven miles southwest of Rock Port, Missouri. The emergency planning zone within the Missouri side of the river is predominantly rural land, except for the towns of Rock Port, population 1,318, Phelps City, population 24, Langdon, population 32, and Watson, population 100. Atchison County is primarily affected by the emergency planning zone (see Figure 3.3.17.5) and is intersected by

several major highways, including Interstate 29, U.S. Highway 136, U.S. Highway 275, and Missouri Highway 111. The total population at risk from a radiological incident in Atchison County is as follows: within 2 miles, approximately 7 people; within 5 miles, approximately 294 people; and within 10 miles, approximately 2,215 people. The plant which opened in July 1974 employees approximately 750 regular full-time employees. The license for this power plant is set to expire in January 2014.

Figure 3.3.17.5 - Emergency Planning Zone for Cooper Nuclear Station

Source: State Hazard Analysis, December 2012

Measure of Probability and Severity
Probability: Moderate
Severity: Moderate
The consequences of a radiological incident originating from one of the commercial nuclear power plants affecting the State can range in severity from insignificant to a high degree of radioactive contamination within the two to 10-mile radius surrounding the facility. The most crucial concerns during a severe incident are safe evacuation and controlled access to the areas affected by a release of radioactive materials. In the aftermath, the main concerns are as follows: the extent of property needing to be decontaminated, contaminated food sources, and the time required to reach acceptable exposure rates and to allow the safe reentry of the public. Historically, due to their safe operation records, fixed nuclear facilities have not represented a high risk to the State. The Reactor Safety Study conducted by the NRC rated the chances of a major nuclear disaster as moderate (a probability of one in one million per plant operating year). The report concluded that the worst accident type that could affect a nuclear power plant would be one resulting in a meltdown, which could be expected to occur in a once out of 20,000 annual chance of reactor operations. The report also stated that a meltdown would likely cause less than one fatality or injury. This moderate hazard rating is due to all of the added safety engineered instrumentation used to monitor and shut down nuclear plant systems before any severe damage occurs.

Impact of the Hazard

An incident at a nuclear power plant resulting in a “general emergency” and evacuation (one where a release from the site boundary would be expected) could have a dramatic psychological impact on the uninformed population within the evacuation zone. The utilities and the State have an active Radiological Emergency Preparedness program to prepare local jurisdictions and the general population surrounding the plant for responding to such an incident. This program includes in-depth training of resources both from the State and local jurisdictions, and regularly scheduled drills and exercises evaluated by FEMA. Extensive planning has focused on implementation of the emergency response plan for both the State and local jurisdictions. Emphasis is placed on prompt notification of emergency organizations and the public; evacuation routes; reception and care centers for evacuees; monitoring for radiological contamination; emergency worker preparedness; and public information in the form of brochures distributed to residents within the emergency preparedness zone. These programs are essential to the protection of the general public.

A past survey was completed of Missouri fire departments across the State, asking their perception of their own capabilities to respond to a radiological incident. Of the 433 departments surveyed, only 118 responded. Of those, 21 believed they could adequately handle a radiological incident until proper authorities arrive.

This indicates that pockets of adequate radiological response capabilities are available throughout the State. However, the main transportation corridors have some gaps which can cause a lag in response time to radiological incidents. It is also clear that more training needs to be encouraged along these corridors. The same consideration must be given to any county located under commercial flyways or where it might be possible for a fallen satellite to leave a contaminated “footprint” (COSMOS 954 left a 200-mile footprint in the Northwest Territory of Canada in 1978).

The information in Table 3.3.17f is from the Impact Analysis of Potential for Detrimental Impacts of Hazards done for the Emergency Management Accreditation Program.

Table 3.3.17f EMAP Impact Analysis: Nuclear Power Plants

Subject	Detrimental Impacts
Health and Safety of Persons in the Area at Time of Incident	Adverse impact expected to be severe for unprotected personnel and moderate to light for protected personnel.
Health and Safety of Personnel Responding to the Incident	Adverse impact expected to be severe for unprotected personnel and moderate to light for trained and protected personnel.
Continuity of Operations	Damage to facilities/personnel in the area of the incident may require temporary relocation of operations.
Property, Facilities, and Infrastructure	Localized impact to facilities and infrastructure in the area of the incident. Some severe damage possible.
Delivery of Services	Localized disruption of lines of communication and destruction of facilities may postpone delivery of some services.
The Environment	May cause extensive damage in isolated cases and some denial or delays in the use of some areas. Remediation needed.
Economic and Financial Condition	Local economy and finances adversely affected, possibly for an extended period of time, depending on damage and length of investigation.
Regulatory and Contractual Obligations	Regulatory requirements must be fulfilled. Fulfillment of some contracts may be difficult. Impact may reduce deliveries.
Reputation of or Confidence in the Entity	Ability to respond and recover may be questioned and challenged if planning, response, and recovery not timely and effective.

Synopsis

Nuclear reactors have been designed to survive natural disasters such as tornadoes and earthquakes without damage to critical systems. Considerable emphasis is placed on multiple-level governmental reviews of the design, construction, and operation of each nuclear power plant. These safety reviews begin prior to construction and continue throughout the operating life of the plant. Radiological planning and preparedness programs monitored by state and federal agencies are in place to ensure that emphasis is placed on the safety of the general public within the emergency planning zone. In addition, the historical record for nuclear power plants gives no indication that a serious accident involving a nuclear power plant will occur. See Section 3.5.17 for additional information regarding vulnerability to this hazard.

3.3.18 Public Health Emergencies/Environmental Issues

Description of Hazard

Public health emergencies can take many forms—disease epidemics, large-scale incidents of food or water contamination, or extended periods without adequate water and sewer services. There can also be harmful exposure to chemical, radiological, or biological agents, and large-scale infestations of disease-carrying insects or rodents. The first part of this section focuses on emerging public health concerns and potential pandemics, while the second part addresses natural and human-caused air and water pollution.

Public health emergencies can occur as primary events by themselves, or they may be secondary to another disaster or emergency, such as tornado, flood, or hazardous material incident. The common characteristic of most public health emergencies is that they adversely impact, or have the potential to adversely impact, a large number of people. Public health emergencies can be worldwide or localized in scope and magnitude.

In particular, two public health hazards have recently emerged as issues of great concern, with far reaching consequences. One pertains to the intentional release of a radiological, chemical, or biological agent, as a terrorist act of sabotage to adversely impact a large number of people. For more information on biochemical terrorism, see Section 3.3.20. The second hazard concerns a deadly outbreak (other than one caused by an act of terrorism) that could kill or sicken thousands of people across the county or around the globe, as in the case of the Spanish Flu epidemic of 1918–1919.

Whether natural or manmade, health officials say the threat of a dangerous new strain of influenza virus in pandemic proportions is a very real possibility in the years ahead. Unlike most illnesses, the flu is especially dangerous because it is spread through the air. A classic definition of influenza is a respiratory infection with fever. Each year, flu infects humans and spreads around the globe. There are three types of influenza virus: Types A, B, and C. Type A is the most common, most severe, and the primary cause of flu epidemics. Type B cases occur sporadically and sometimes as regional or widespread epidemics. Type C cases are quite rare and hence sporadic, but localized outbreaks have occurred. Seasonal influenza usually is treatable, and the mortality rate remains low. Each year, scientists estimate which particular strain of flu is likely to spread, and they create a vaccine to combat it. A flu pandemic occurs when the virus suddenly changes or mutates and undergoes an "antigenic shift," permitting it to attach to a person's respiratory system and leave the body's immune system defenseless against the invader.

Environmental concerns addressed in this profile focus on air and water pollution, because contamination of those media can have widespread impacts on public health and devastating consequences. Particular issues of primary concern associated with sources of air and water pollution change over time depending on recent industrial activity, economic development, enforcement of environmental regulations, new scientific information on adverse health effects of particular contaminants or concentrations, and other factors.

Historical Statistics

Influenza Pandemics

Since the early 1900s, three lethal pandemics have swept the globe, although none have compared to the infamous Spanish Flu event of 1918–1919, which killed more than 20 million people. Its primary victims were mostly young, healthy adults. The 1957 Asian Flu pandemic killed about 70,000 people in

the United States, mostly the elderly and chronically ill. The 1968 Hong Kong Flu pandemic killed 34,000 Americans. In addition to those three pandemics, several “pandemic scares” have occurred.

Spanish Flu of 1918-1919
In 1918, the Spanish Flu swept the world in three waves during a two-year period.

The first reported case occurred at Camp Funston (Fort Riley), Kansas, where 60,000 soldiers trained to be deployed overseas. Within four months, the virus traversed the globe, as American soldiers brought the virus to Europe. The first wave sickened thousands of people and caused many deaths (46 died at Camp Funston), but it was considered mild compared to what was to come. The second and deadliest wave struck in the autumn of 1918 and killed millions. At Camp Funston alone, there were 14,000 cases and 861 deaths reported during the first three weeks of October 1918.

Outbreaks caused by a new variant exploded almost simultaneously in many locations, including France, Sierra Leone, Boston, and New York City, where more than 20,000 people died that fall. The flu gained its name from Spain, which was one of the hardest hit countries. From there, the flu went through the Middle East and around the world, eventually returning to the United States along with the troops.

Of the 57,000 Americans who died in World War I, 43,000 died as a result of the Spanish Flu. At one point, more than 10 percent of the American workforce was bedridden. By a conservative estimate, a fifth of the human race suffered the fever and aches of influenza between 1918 and 1919 and 20 million people died.

In 1918, Missouri’s influenza death rate was 293.83 per 100,000 people, for a total of 9,677 deaths statewide from that cause alone. That figure represents 18.6 percent of Missouri’s total deaths that year. While the cause of the Spanish Flu remains somewhat a mystery, the epidemic was generally traced to pigs on Midwest farms, which then spread the deadly virus to farm families. As fall crops were ready for harvest in 1918, there were no field hands to get the crops in, thereby creating an agricultural disaster as well.

A third wave of the Spanish Flu, much less devastating than its predecessors, made its way through the world in early 1919 and then died out. Missouri’s flu death rate in 1919 dropped to less than half that of the previous year (107.21 per 100,000), and by 1921, it was reduced to 87.24 deaths per 100,000 people, state statistics show.

Asian Flu of 1957
This flu pandemic was first identified in February 1957 in the Far East. Unlike the Spanish Flu, the 1957 virus was quickly identified, and vaccine production began in May 1957. A number of small outbreaks occurred in the United States during the summer of 1957, with infection rates highest among school children, young adults, and pregnant women; however, the elderly had the highest rates of death. A second wave of infections occurred early the following year, which is typical of many pandemics.
Hong Kong Flu of 1968
This influenza pandemic was first detected in early 1968 in Hong Kong. The first cases in the United States were detected in September 1968, although widespread illness did not occur until December. This became the mildest pandemic of the twentieth century, with those over the age of 65 the most likely to die. People infected earlier by the Asian Flu virus may have developed some immunity against

the Hong Kong Flu virus. Also, this pandemic peaked during school holidays in December, limiting student-related infections.

Flu Scares: Swine Flu of 1976, Russian Flu of 1977, and Avian Flu of 1997

Three notable flu scares occurred in the twentieth century. In 1976, a swine-type influenza virus appeared in a U.S. military barracks (Fort Dix, New Jersey). Scientists determined it was an antigenically drifted variant of the feared 1918 virus. Fortunately, a pandemic never materialized, although the news media made a significant argument about the need for a Swine Flu vaccine.

In May 1977, influenza viruses in northern China spread rapidly and caused epidemic disease in children and young adults. By January 1978, the virus, subsequently known as the Russian Flu, had spread around the world, including the United States. A vaccine was developed for the virus for the 1978–1979 flu season. Because illness occurred primarily in children, this was not considered a true pandemic.

In March 1997, scores of chickens in Hong Kong's rural New Territories began to die—6,800 on three farms alone. The Avian Flu virus was especially virulent, and made an unusual jump from chickens to humans. At least 18 people were infected, and six died in the outbreak. Chinese authorities acted quickly to exterminate over one million chickens and successfully prevented further spread of the disease.

Avian Flu (H5N1)

The Avian flu (H5N1) is a Type A influenza virus that occurs mainly in birds and is highly contagious among birds. The Avian Flu virus was especially virulent, and made an unusual jump from chickens to humans. At least 18 people were infected, and six died in the outbreak. Since 2003, a growing number of human H5N1 cases have been reported in Asia, Europe, and Africa. More than half of the people infected with the H5N1 virus have died. Most of these cases are all believed to have been caused by exposure to infected poultry. There has been no sustained human-to-human transmission of the disease, but the concern is that H5N1 will evolve into a virus capable of human-to-human transmission. Scientists are concerned that as H5N1 continues to evolve, it could make humans more susceptible to infection. Since humans have little or no immune protection against H5N1, such a change could spark an influenza pandemic with potentially high rates of illness and death. For treatment (and prevention) of human infection with avian influenza A viruses, the Center for Disease Control and World Health Organization currently recommend oseltamivir or zanamivir, two of four prescription antiviral medications currently licensed for use in the United States.. Researchers are working to produce alternative treatments. Thailand has begun a phase 1 clinical trial to test an H5N1 avian, or bird, influenza vaccine in a needle-free, nasal spray form. This trial is a result of international collaboration with health agencies around the world, including the U.S. Department of Health and Human Services' Biomedical Advanced Research and Development Authority (BARDA). The study and data analysis is expected to be complete by May 2013.

Other Diseases of Public Health Concern

Smallpox

Smallpox is a contagious, sometimes fatal, infectious disease. There is no specific treatment for smallpox disease, and the only prevention is vaccination. Smallpox is caused by the variola virus that emerged in human populations thousands of years ago. It is generally spread by face-to-face contact or by direct contact with infected bodily fluids or contaminated objects (such as bedding or clothing). A person with smallpox is sometimes contagious with onset of fever, but the person becomes most contagious with

the onset of rash. The rash typically develops into sores that spread over all parts of the body. The infected person remains contagious until the last smallpox scab is gone. Smallpox outbreaks have occurred periodically for thousands of years, but the disease is now largely eradicated after a worldwide vaccination program was implemented. After the disease was eliminated, routine vaccination among the general public was stopped. The last case of smallpox in the United States was in 1949.

It should be noted that after recent terrorist events in the United States, there is heightened concern that the variola virus might be used as an agent of bioterrorism. For this reason, the U.S. government is taking precautions for dealing with a smallpox outbreak. For further information on this issue, see Section 3.3.20 Terrorism.

St. Louis Encephalitis

In the United States, the leading type of epidemic flaviviral encephalitis is St. Louis encephalitis (SLE), which is transmitted by mosquitoes that become infected by feeding on birds infected with the virus. SLE is the most common mosquito-transmitted pathogen in the United States. There is no evidence to suggest that the virus can be spread from person to person.

Between 1964 and 2010, there were 4,693 confirmed cases of SLE in the United States. Seventy-seven of these cases were in Missouri. According to the Center for Disease Control, there was one case of SLE in Missouri in 2010. It should be noted, however, that less than 1 percent of SLE infections are clinically apparent, so the vast majority of infections remain undiagnosed. Illnesses range from mild headaches and fever to convulsions, coma, and paralysis. The last major outbreak of SLE occurred in the Midwest from 1974 to 1977, when over 2,500 cases were reported in 35 states. The most recent outbreak of St. Louis encephalitis was in 2001 in Monroe and West Monroe, Louisiana, with 63 reported cases. The disease is generally milder in children than in adults, with the elderly at highest risk for severe illness and death. Approximately 3 to 30 percent of cases are fatal; no vaccine against SLE exists.

Meningitis

Meningitis is an infection of fluid that surrounds a person’s spinal cord and brain. High fever, headache, and stiff neck are common symptoms of meningitis, which can develop between several hours to one to two days after exposure. Meningitis can be caused by either a viral or bacterial infection; however, a correct diagnosis is critically important, because treatments for the two varieties differ. Meningitis is transmitted through direct contact with respiratory secretions from an infected carrier. Primary risk groups include infants and young children, household contact with patients, and refugees. The disease is of most concern in Africa, where 213,658 cases were reported during 1996–1997, with 21,830 deaths. In the United States, periodic outbreaks continue to occur, particularly among adolescents and young adults. About 2,600 people in the United States get the disease each year. According to the Missouri Department of Health and Senior Services, there were 23 cases in Missouri in 2010. Generally, 10 to 14 percent of cases are fatal, and 11 to 19 percent of those who recover suffer from permanent hearing loss, mental retardation, loss of limbs, or other serious effects. Two vaccines are available in the United States.

Lyme Disease

Lyme disease was named after the town of Lyme, Connecticut, where an unusually large frequency of arthritis-like symptoms was observed in children in 1977. It was later found that the problem was caused by bacteria transmitted to humans by infected deer ticks, causing an average of more than 16,000 reported infections in the United States each year (however, the disease is greatly under-

reported). Lyme disease bacteria are not transmitted from person to person. Following a tick bite, 80 percent of patients develop a red “bulls-eye” rash accompanied by tiredness, fever, headache, stiff neck, muscle aches, and joint pain. If untreated, some patients may develop arthritis, neurological abnormalities, and cardiac problems, weeks to months later. Lyme disease is rarely fatal. During early stages of the disease, oral antibiotic treatment is generally effective, while intravenous treatment may be required in more severe cases.

In the United States, Lyme disease is mostly found in the northeastern, mid-Atlantic, and upper north-central regions, and in several counties in northwestern California but has been reported in every state. In 2005, 23,305 cases of Lyme disease were reported to the Centers for Disease Control and Prevention. According to the DHSS, in 2010, Missouri showed a decreasing trend for the occurrence of Lyme disease with five cases, the lowest since 2009 when 10 cases were reported. There have been no reported cases of Lyme disease that originated in Missouri.

West Nile Virus

West Nile virus is a flavivirus spread by infected mosquitoes and is commonly found in Africa, West Asia, and the Middle East. It was first documented in the United States in 1999. Although it is not known where the U.S. virus originated, it most closely resembles strains found in the Middle East. It is closely related to St. Louis encephalitis and can infect humans, birds, mosquitoes, horses, and other mammals.

Most people who become infected with West Nile virus will have either no symptoms or only mild effects. However, on rare occasions, the infection can result in severe and sometimes fatal illness. There is no evidence to suggest that the virus can be spread from person to person.

An abundance of dead birds in an area may indicate that West Nile virus is circulating between the birds and mosquitoes in that area. Although birds are particularly susceptible to the virus, most infected birds survive. The continued expansion of West Nile virus in the United States indicates that it is permanently established in the Western Hemisphere. As of December 11, 2012, 48 states have reported West Nile virus infections in people, birds, or mosquitoes. A total of 5,387 cases of West Nile virus disease in people, including 243 deaths, have been reported to CDC. The 5,387 cases reported thus far in 2012 is the highest number of West Nile virus disease cases reported to CDC through the second week in December since 2003. Eighty percent of the cases have been reported from 13 states (Texas, California, Louisiana, Illinois, Mississippi, South Dakota, Michigan, Oklahoma, Nebraska, Colorado, Arizona, Ohio, and New York) and a third of all cases have been reported from Texas.

Severe Acute Respiratory Syndrome

Severe acute respiratory syndrome (SARS) is a respiratory illness that has recently been reported in Asia, North America, and Europe. Although the cause of SARS is currently unknown, scientists have detected in SARS patients a previously unrecognized coronavirus that appears to be a likely source of the illness. In general, humans infected with SARS exhibit fevers greater than 100.4°F, headaches, an overall feeling of discomfort, and body aches. Some people also experience mild respiratory symptoms. After two to seven days, SARS patients may develop a dry cough and have trouble breathing.

The primary way that SARS appears to spread is by close person-to-person contact; particularly by an infected person coughing or sneezing contaminated droplets onto another person, with a transfer of those droplets to the victim’s eyes, nose, or mouth. The global outbreak of 2003 was contained. There were no confirmed cases in Missouri.

H1N1 Influenza (Pandemic Influenza)

The H1N1 virus, also known as the swine flu, is a respiratory disease of pigs caused by type A influenza viruses that regularly cause outbreaks of influenza in pigs. This virus is a unique grouping of influenza virus genes never previously seen in either animals or people. The virus genes are a combination of genes most closely related to North American swine-lineage H1N1 and Eurasian lineage swine-origin H1N1 influenza viruses. Due to this combination, initial reports referred to the virus as a swine origin influenza virus. However, investigations of initial human cases did not identify exposures to pigs and quickly it became apparent that this new virus was circulating among humans and not among U.S. pig herds.

The new flu virus spread quickly across the United States and the world in the spring of 2009. The first U.S. case of H1N1 was diagnosed on April 15, 2009. By April 21, the Centers for Disease Control and Prevention (CDC) was working to develop a vaccine for this new virus. The U.S. government declared H1N1 a public health emergency on April 26. By June, 18,000 cases of H1N1 had been reported in the U.S. Additionally, 74 countries were affected by the pandemic. H1N1 vaccine supply was limited in the beginning. People at the highest risk of complications got the vaccine first. By November 2009, 48 states had reported cases of H1N1, mostly in young people. That same month, over 61 million vaccine doses were ready. Reports of flu activity began to decline in parts of the country, which gave the medical community a chance to vaccinate more people. 80 million people were vaccinated against H1N1, which minimized the impact of the illness. The CDC estimates that 43 million to 89 million people had H1N1 between April 2009 and April 2010. They estimate between 8,870 and 18,300 H1N1 related deaths. On August 10, 2010 the World Health Organization (WHO) declared an end to the global H1N1 flu pandemic.

According to the September 1, 2009 H1N1 Virus Briefing document produced by the Missouri Department of Health and Senior Services, the H1N1 virus, also known as swine flu, first emerged in Mexico in March 2009 and caused illness in people worldwide. As of August 23, 2009, the World Health Organization reported over 209,438 laboratory-confirmed cases of H1N1 with 2,185 deaths. Missouri saw its first H1N1 case in April 2009. Since then, the State reported hundreds of confirmed cases and eleven deaths. In Missouri, as well as worldwide, the illness associated with this new virus continued to be similar to the seasonal flu. Most people who have become ill have recovered without requiring medical treatment. However, the virus has been shown to be particularly aggressive in some segments of the population not usually affected by the regular flu. These groups include pregnant women, school-age children, and those with underlying chronic health conditions, such as obesity or asthma.

The H1N1 flu outbreak was serious. In late March and early April 2009, cases of human H1N1 infection were first reported in Southern California and near San Antonio, Texas. For comparison, only 12 human cases of swine flu were detected in the U.S. from December 2005 to February 2009, with no deaths occurring. The last swine flu outbreak in the U.S. was in 1976.

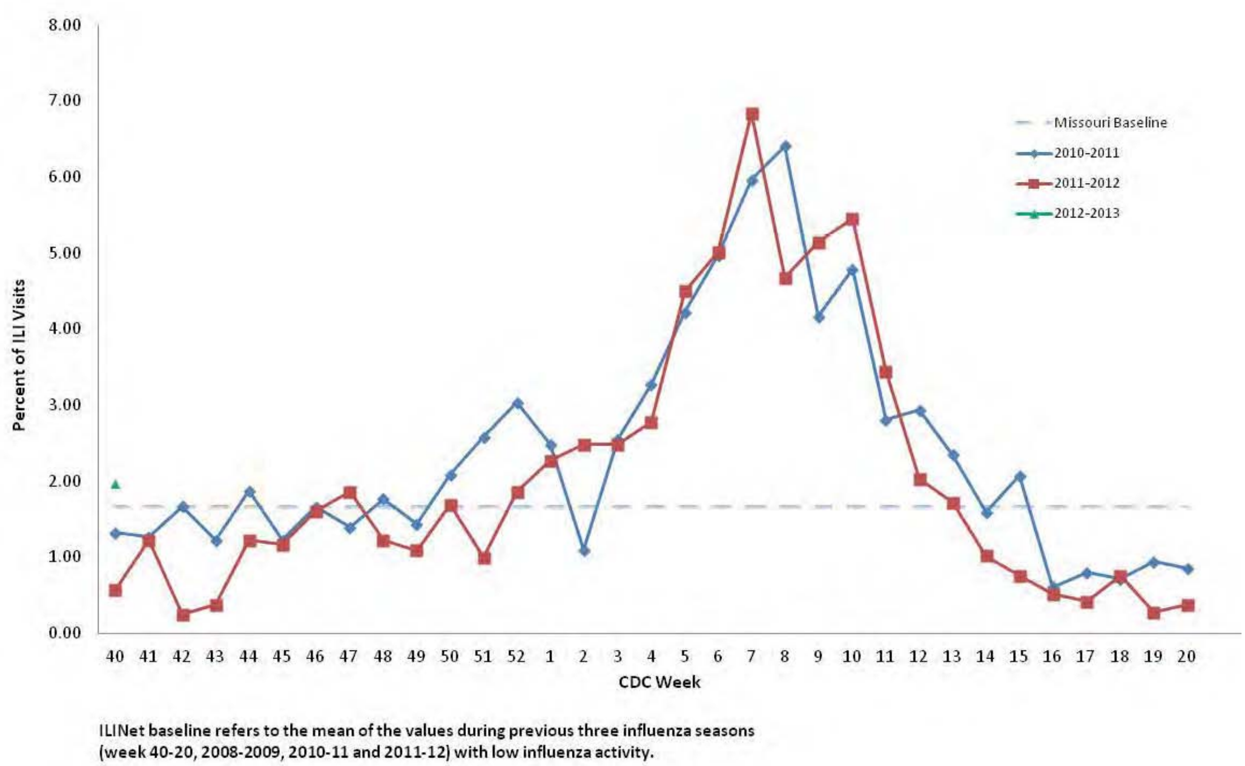
On Friday, April 24, 2009 the State health department issued a Health Advisory to Missouri's medical community and to public health departments. The Health Advisory asked hospital intensive care units to collect influenza specimens from patients with flu-like illness, confirmed influenza, bacterial pneumonia, or lower respiratory illness with fever. The department also asked the existing network of key health care providers to collect specimens from outpatients suffering from those conditions.

The World Health Organization declared this outbreak a worldwide influenza pandemic. The declaration was based on the spread of the virus throughout the world, not on the severity of the illness. The Missouri Department of Health and Senior Services prepared for such a pandemic with its Missouri Pandemic Influenza Response plan. Additional activities included enhanced surveillance for the H1N1 virus by requiring immediate, detailed reporting of all diagnosed or suspected cases; conducting more frequent analysis of surveillance data; and activating additional surveillance providers. The State Public Health Laboratory in Jefferson City is a state-of-the-art facility that handles many kinds of infectious agents.

The department's flu Web site, http://health.mo.gov/living/healthcondiseases/communicable/influenza/index.php, has specific advice for child care centers, employers, nursing homes, schools, pregnant women, restaurant workers and customers and stroke patients. The department also provides advice, information and leadership to local public health agencies and to the medical community on ways to deal with pandemic outbreak and works closely with the news media to disseminate information about the virus."

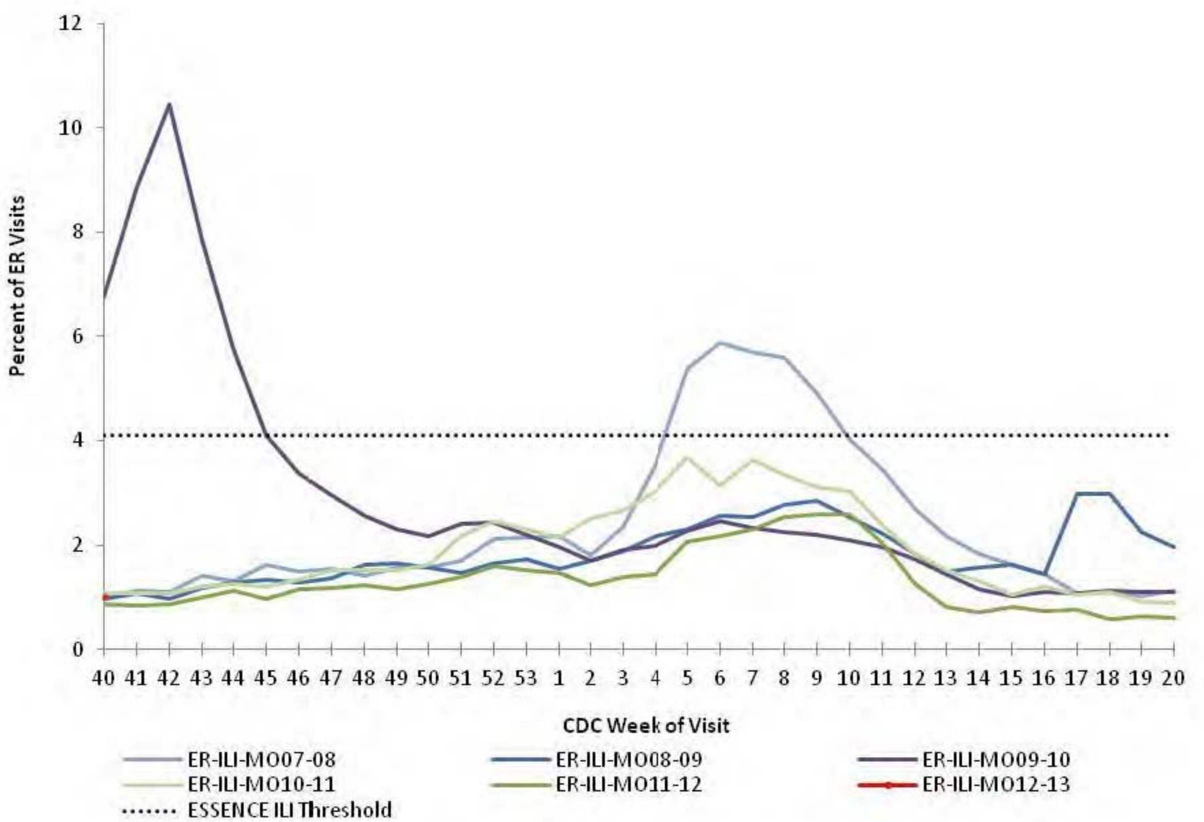
Specific Information regarding the current situation as of October 2012 with flu viruses in Missouri are included in Figure 3.3.18.1 and Figure 3.3.18.2.

Figure 3.3.18.1 - Percentage of Visits for Influenza-like-Illness (ILI) Reported by the Missouri Outpatient ILI Surveillance Network (ILINet) 2012-2013 Season-To-Date as compared to the previous two influenza seasons Through the Week Ending October 6, 2012 (Week 40)



Source: Missouri Department of Health and Senior Services Bureau of Communicable Disease Control and Prevention http://health.mo.gov/living/healthcondiseases/communicable/influenza/pdf/Week401213.pdf

Figure 3.3.18.2 - Weekly Percentage of Influenza-like Illness Chief Complaints, in ESSENCE Participating Hospitals, 2007-2013 Through the Week Ending October 6, 2012 (Week 40)



Source: Missouri Department of Health and Senior Services Bureau of Communicable Disease Control and Prevention http://health.mo.gov/living/healthcondiseases/communicable/influenza/pdf/Week401213.pdf
*ESSENCE ILI Threshold refers to the mean plus 3 standard deviations of the values during previous influenza seasons (week 40-20, 2007-2008, 2008-2009, 2009-2010, 2010-2011, and 2011-2012) when influenza activity was low.

Environmental Incidents

For information regarding historical incidents involving air and water pollution in Missouri, see Section 3.3.15 Hazardous Materials.

Measure of Probability and Severity

Probability: High
Severity: Moderate to High
During the 2012 drafting of this plan, there was concern among health officials that there was a high probability of a dangerous new strain of the influenza virus sometime in the future. In fact, they believed that worldwide influenza outbreak on the scale and severity of the Spanish Flu was not far-fetched. Catastrophic consequences were predicted. A much larger percentage of the world's population is clustered in cities, making them ideal breeding grounds for epidemics. Additionally, the explosive growth in air travel means the virus could literally be spread around the globe within hours. Under such conditions, there may be very little warning time. Most experts believe we will have just one to six months between the time that a dangerous new influenza strain is identified and the time that outbreaks begin to occur in the United States. Outbreaks are expected to occur simultaneously

throughout much of the nation, preventing shifts in human and material resources that normally occur with other natural disasters. These and many other aspects make influenza pandemic unlike any other public health emergency or community disaster.

Environmental concerns are also on the rise, with recent scientific data emphasizing the long-term impacts that air and water pollution can have on the ecology of affected areas. With continued enforcement of regulatory standards for airborne releases and discharges to waterways, routine emissions by industrial facilities are relatively easy to monitor and control. However, the potential always remains for unauthorized dumping and releases and for failure of systems to control industrial discharges, resulting in potential environmental emergencies.

Impact of the Hazard

For planning purposes, it is reasonable to assume a rapid movement of a pandemic flu virus from major metropolitan areas to rural areas of the State. The effect of a pandemic on individual communities would likely be relatively prolonged—weeks to months. The impact of the next pandemic could have a devastating effect on the health and well-being of Missouri citizens and the American public. For such an outbreak in the future, the Centers for Disease Control and Prevention estimate that in the United States alone:

- Up to 200 million persons will be infected
- Between 40 and 100 million persons will become clinically ill
- Between 18 and 45 million persons will require outpatient care
- Between 300,000 and 800,000 persons will be hospitalized
- Between 88,000 and 300,000 people will die nationwide
- Effective preventive and therapeutic measures, including vaccines and antiviral agents, likely will be in short supply, as well as some antibiotics to treat secondary infections
- Economic losses from the next pandemic may range from $500 to $675 billion, depending on the attack rate (Reuters)

Compared to public health emergencies, as previously described, environmental incidents involving air and water pollution would likely impact a more localized area; however, long-term effects on the environment in the impacted area could linger for many years.

The information in Table 3.3.18a is from the Impact Analysis of Potential for Detrimental Impacts of Hazards done for the Emergency Management Accreditation Program. The table explains possible impacts to various subjects due to health or environmental emergencies.

Table 3.3.18a EMAP Impact Analysis: Public Health Emergencies/Environmental Issues

Subject	Detrimental Impacts
Health and Safety of Persons in the Area at Time of Incident	Adverse impact expected to be severe for unprotected personnel and moderate to light for protected personnel.
Health and Safety of Personnel Responding to the Incident	Adverse impact expected to be severe for unprotected personnel and uncertain for trained and protected personnel, depending on the nature of the incident.
Continuity of Operations	Danger to personnel in the area of the incident may require relocation of operations and lines of succession execution.

Subject	Detrimental Impacts
Property, Facilities, and Infrastructure	Access to facilities and infrastructure in the area of the incident may be denied until decontamination completed.
Delivery of Services	Disruption of lines of communication and destruction of facilities may extensively postpone delivery of services.
The Environment	Incident may cause denial or delays in the use of some areas. Remediation needed.
Economic and Financial Condition	Local economy and finances adversely affected, possibly for an extended period of time.
Regulatory and Contractual Obligations	Regulatory waivers may be needed. Fulfillment of contracts may be difficult. Demands may overload ability to deliver.
Reputation of or Confidence in the Entity	Ability to respond and recover may be questioned and challenged if planning, response, and recovery not timely and effective.

Synopsis

Public Health Emergencies

Preparing for, responding to and recovering from pandemic influenza will require a strategy with many similarities to other disease outbreaks, be they naturally occurring or resulting from terrorist action. The time-honored public health activities to lessen the impact on morbidity and mortality such as education, vaccination, prophylaxis, isolation/quarantine and the closure of public facilities are common to all, despite the particular disease of concern. In addition, clear, concise communication with the public, within the Missouri Department of Health and Senior Services (DHSS), and with other agencies remains a critical component, as does the ability of the involved agencies to achieve collaboration and coordination. By its very nature, an influenza pandemic, once started, will not be stopped until it has run its course. This course can be shortened and weakened by many things, with vaccination being the gold standard for protecting the population. Pandemic plans describe strategies of preparedness, response and recovery to attempt to decrease illnesses and deaths during the pandemic period to manageable levels (i.e., that do not overwhelm the critical infrastructures of the State), and to promote community resiliency and rapid recovery.

DHSS has emergency pandemic flu response plans in place, internally, and as part of the State response through the Missouri State Emergency Operations Plan (SEOP) that have been tried, tested and exercised for all aspects of response and recovery, including those mentioned above relating to disease surveillance, investigation and control. Where necessary, details or public information templates unique to pandemic influenza have been added into plans. The current pandemic plan gives background information related to pandemic influenza, outlines the DHSS concept of operations for response, lists primary and support functional areas and provides technical support annexes outlining the available resources (i.e., “tools”) available to temper the pandemic and promote community resiliency and recovery. Components of other all-hazard plans incorporated through partnership with the State Emergency Management Agency and other local, state, and federal agencies are expected to be utilized in accordance with need.

A broad, diverse and geographically dispersed group of agencies and organizations, representing the length, breadth and interests of the State collaborated with the DHSS in working to prepare for pandemic influenza. With committees organized under the umbrella of the Missouri Homeland Security Advisory Council, over four hundred representatives from hospitals, livestock corporations, local public health agencies (LPHAs), other state agencies, funeral homes, laboratories, financial institutions, fire

departments, local and state governments, school boards, utility companies, universities, nursing homes and coroner's offices, among others, engaged with DHSS providing input and expertise to produce the Missouri Pandemic Influenza Response Plan. For more information go to http://www.dps.mo.gov/homelandsecurity/safeschools/documents/Missouri%20PanFluPlan.pdf.

DHSS has primary responsibility to safeguard the health of the people of the State and all its subdivisions and will respond in the event of pandemic influenza to attempt to limit the impact on public health by reducing morbidity and mortality. These actions may also limit the impact on the social and economic infrastructure of the State. DHSS will serve to support the LPHAs in this effort, and lead the State-level response of a coordinated multitude of federal, state and private organizations and agencies. DHSS reserves the flexibility to modify the plan during the pandemic in response to the actual behavior of the disease and the effectiveness of the ongoing response. Lessons learned from previous waves will be incorporated going forward and modifications in planning may be made across all sectors to meet the key goals in public health and critical infrastructure support. Such changes will be rapidly and effectively communicated from DHSS to all partnered agencies and organizations per the communications plan to ensure best practices are consistently implemented statewide.

Environmental Issues

Although Missouri has never had an environmental disaster of large proportions, there are many instances where hazardous substances can impact the environment with considerable consequences to either air or water. Floods often temporarily interrupt community water supplies, creating the need for emergency potable water for thousands of people. In July 1993, for example, St. Joseph's municipal water plant was forced to shut down for an extended period when contaminated floodwater threatened to enter the system. Floodwaters also disrupt wastewater treatment facilities, resulting in the discharge of raw or improperly treated sewage. Periodically, water pollutants cause fish kills in Missouri streams, and excessive air pollutants associated with smog in large metropolitan areas create public health problems.

In 1983, the town of Times Beach, located in St. Louis County, was evacuated due to dioxin contamination. Dioxin is chemical compound found to cause severe health effects when high levels of exposure occur. In the 1920s and 30s, the town was a summer resort but had since become a low-middle class town. Due to the dust problem from unpaved roads, a local waste hauler was hired to spray waste oil in and around the town on the dirt roads. The waste hauler had also been hired by a local company to dispose of toxic waste. The toxic waste came from a facility in western Missouri that had once produced Agent Orange during the Vietnam War. The hauler was unaware of the dioxin content and mixed it with the oil being sprayed. A problem first arose when 62 horses died after the mixture was sprayed in a stable to mitigate dust. On December 5, 1982, the Meramec River flooded causing an evacuation due to more than 95% of the town being under ten feet of water. On December 23, 1982 the EPA announced that dangerous levels of dioxin were found in the soil around Times Beach. By 1985, the Times Beach was evacuated. It was later found that the waste contained 2,000 times the amount of dioxin content of Agent Orange. It was the largest civilian exposure to dioxin in the county's history.

Air Pollution

Staff in the State of Missouri Air Quality Monitoring section operates approximately 140 instruments at 40 locations around the State as part of a network to monitor air pollutants known to affect people's health. In addition, staff conducts special air quality studies http://www.dnr.mo.gov/env/esp/aqm/esp-aqm.htm. For more information go to http://www.dnr.mo.gov/env/apcp/index.html

Because of high amounts of ozone, carbon dioxide, nitrogen compounds, and other vehicular pollutants in the St. Louis metropolitan area, vehicles registered in the counties of St. Louis, St. Charles, and Jefferson, as well as St. Louis City, are required to have their exhaust systems routinely checked to determine whether emissions standards are being achieved. In addition, all service stations around St. Louis are now required to have new gas nozzles that recapture gasoline vapors, thus preventing them from being released to the atmosphere. These vapors (unburned hydrocarbons) chemically react with nitrogen oxides when exposed to the sunlight and form ozone, which is the basis for smog. For more information on Missouri's Air Pollution Control Program, contact the Missouri Department of Natural Resources at www.dnr.mo.gov/.

The EPA maintains a list of facilities that release the most toxic chemicals each year. Missouri's top 10 facilities for 2003 are shown in Table 3.3.18b. The top 10 chemicals released in the State are shown in Table 3.3.18c. The information is recorded by on site and off site releases. The onsite releases are based upon detected releases of material into the air, land and water. Off-site releases are divided between publicly own treatment works and disposal.

Table 3.3.18b Top 10 Facilities in Missouri Showing Greatest Releases (2011) (All figures are in pounds)

	On-Site Releases				Off-Site Releases		
Facility	County	Air	Land	Water	POTW*	Disposal	Total**
Buick Mine/Mill	Iron	54,404	25,258,000	40,619	138,495	7031	25,505,888
Brushy Creek Mine/mill	Reynolds	39,409	8,810,000	13,277	135,793	7031	9,012,849
Doe Run Co. Herculaneum Smelter	Jefferson	63,513	7,874,520	197	32,622	23,286	8,018,655
Ameren Missouri Sioux Energy Center	St. Charles	3,687,415	5,162,548	159	439	439	8,851,002
Ameren Missouri Rush Island Energy Center	Jefferson	3,144,369	4,754,205	116	0	225	7,899,142
Fletcher Mine/Mill	Reynolds	28,731	6,970,000	380,954	1	294	7,380,277
AmerenUE Missouri Meramec Energy Center	St. Louis City	2,620,808	3,943,463	29	0	0	6,564,651
Sweetwater Mine/Mill	Reynolds	18,718	4,016,000	3,710	0	396	4,039,221

Facility	On-Site Releases				Off-Site Releases		
	County	Air	Land	Water	POTW*	Disposal	Total**
AmerenUE Labadie Power Plant	Franklin	1,222,914	2,759,968	12	0	105.4	3,983,105
Associated Electric Cooperative Inc.	New Madrid	319,623	2,119,000	3,271	0	30	2,441,954

Source: EPA TRI.NET Database 2011Notes: *Releases to POTWs (publicly owned treatment works) of metals or metal compounds only

**None of the values in this table include Dioxin or Dioxin-like compounds

Table 3.3.18c Top 10 Chemicals Reported in Missouri (2011) (All figures are in pounds)

Chemical	On-Site Releases			Off-Site Releases		
	Air	Land	Water	POTW*	Disposal	Total*
Lead Compounds	102,560	22,381,451	14,880	1,085	234,003	22,969,072
Zinc Compounds	457,124	16,439,837	36,843	6,783	430,925	17,809,223
Barium Compounds	92,493	10,583,657	7,509	39	26,461	10,736,581
Copper Compounds	12,375	5,742,977	1,125	4,135	60,858	5,886,466
Aluminium (fume or dust)	1,867	1,798,707	0	0	68,397	1,937,368
Hydrogen Fluoride	1,823,251	0	0	0	22,318	1,867,887
Sulfuric Acid	1,740,778	0	0	0	0	1,740,778
Nitrate Compounds	3,181	5	1,615,075	1,427,108	35,255	1,688,771
Hydrochloric Acid ("acid aerosols" only)	1,249,723	5	0	0	0	1,249,723
Manganese	10,642	371,557	634	17,577	308,413	1,034,413

Source: EPA TRI.NET Database 2011

Note: *These numbers include transfers of non-metals to POTWs (publicly owned treatment works), but transfers of non-metals to POTWs are considered off-site treatment, not releases to the environment, and are NOT included in the Total Releases column

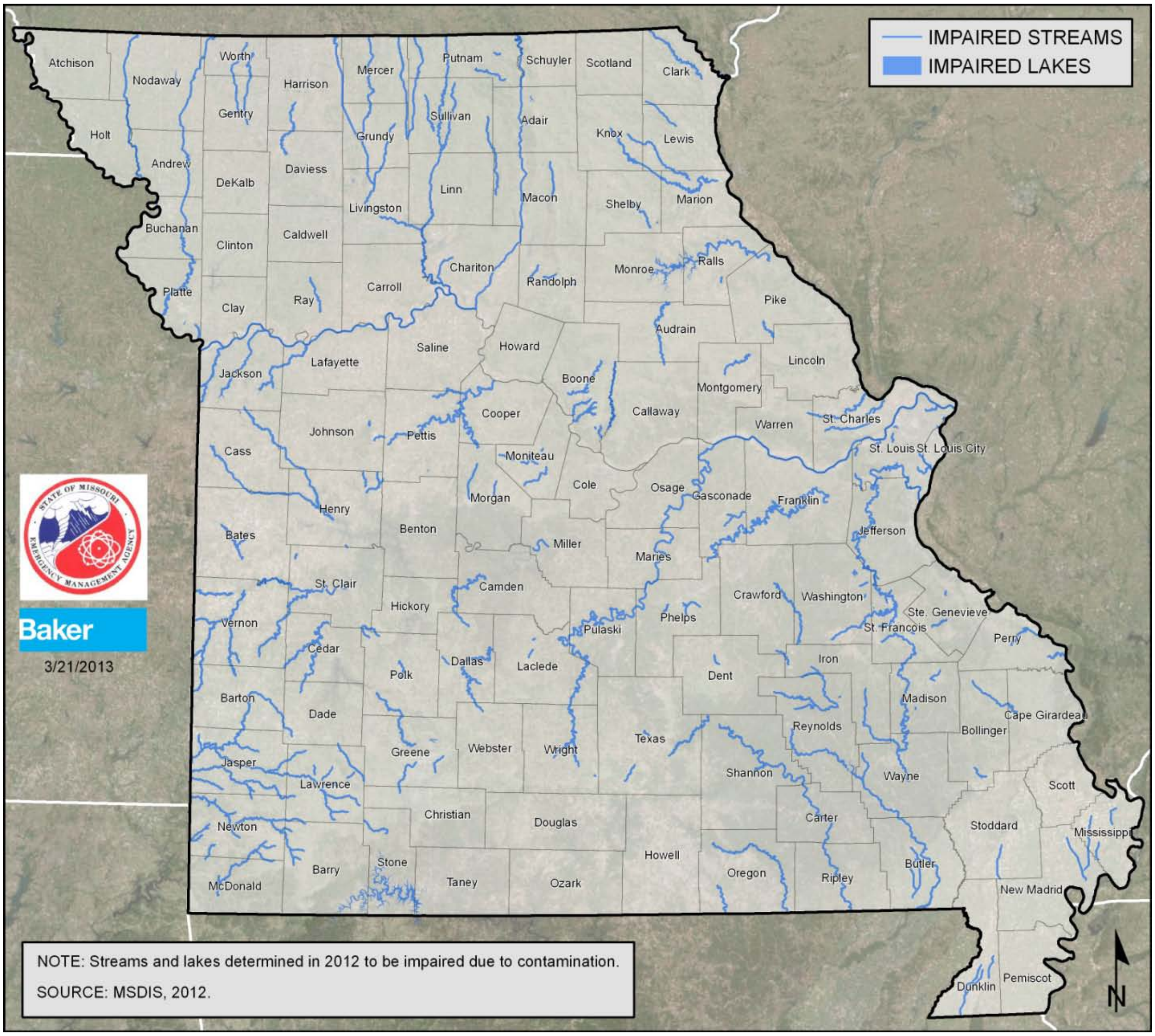
Because of high amounts of ozone, carbon dioxide, nitrogen compounds, and other vehicular pollutants in the St. Louis metropolitan area, vehicles registered in the counties of St. Louis, St. Charles, and Jefferson, as well as St. Louis City*, are required to have their exhaust systems routinely checked to determine whether emissions standards are being achieved. In addition, all service stations around St. Louis are now required to have new gas nozzles that recapture gasoline vapors, thus preventing them from being released to the atmosphere. These vapors (unburned hydrocarbons) chemically react with nitrogen oxides when exposed to the sunlight and form ozone, which is the basis for smog. For more

information on Missouri's Air Pollution Control Program, contact the Missouri Department of Natural Resources.

Water Pollution

The Missouri Department of Natural Resources also maintains the State's water quality management plan and has developed individual plans for each drainage basin in Missouri. Those drainage basins may be divided into the following geographic categories: Upper Mississippi River tributaries, Lower Mississippi River tributaries, Missouri River tributaries north of the Missouri River, Missouri River tributaries south of the Missouri River, White River tributaries, and Arkansas River tributaries. For the most up to date information on water pollution go to http://www.dnr.mo.gov/env/wpp/index.html. According to the Missouri Division of Natural Resources Missouri Water Quality Report from 2012, Missouri has an area of 68,742 square miles and a population of 6 million people. About half of the population is concentrated on opposite sides of the State in the Kansas City and St. Louis metro areas, leaving most of the State and its waters rural in nature. Surface and groundwater in Missouri are quite varied in quantity and quality, corresponding closely with geology and land use. There are currently 24,431 miles of classified streams in Missouri, 30,000 miles of unclassified streams, and 450 classified lakes totaling 302,867 acres. Figure 3.3.18.3 below represents the streams and lakes that the 2012 Missouri Water Quality Report deems impaired due to contamination. The report can be found at: http://www.dnr.mo.gov/env/wpp/waterquality/305b/2012-305b.pdf.

Figure 3.3.18.3 - Streams and Lakes Deemed Impaired by the 2012 Missouri Water Quality Report



According to the 2012 Water Quality Report, state concerns include the following:

- Channelization has caused aquatic habitat degradation in 32 percent of Missouri's streams and contributes to flooding, high water velocities, and streambank erosion as they try to recreate their natural sinuosity.
- Eutrophication of large, recreationally important reservoirs continues to be a concern.
- Abandoned lead-zinc mines and their tailings continue to impact waters decades after mining has ceased. Missouri's Superfund Program is addressing some of these concerns.
- Additional ground water protection measures are needed.
- There are 427 Class I confined animal feeding operations in Missouri.
- The data on fish that have been collected and the data on invertebrates that are still being collected indicate that many of these communities throughout the State are suffering from degraded quality of aquatic habitat.

For more information on Missouri's Water Pollution Control Program, contact the Missouri Department of Natural Resources at (573) 751-1300 or visit http://www.dnr.mo.gov/env/wpp/index.html.

In addition to State water pollution management, the Environmental Protection Agency (EPA) maintains the National Pollutant Discharge Elimination System (NPDES). Authorized by the Clean Water Act, the NPDES permit program controls water pollution by regulating point sources that discharge pollutants into waters of the United States. Point sources are discreet conveyances such as pipes or man-made ditches. Individual homes that are connected to a municipal system, use a septic system, or do not have a surface discharge do not need an NPDES permit; however, industrial, municipal, and other facilities must obtain permits if their discharges go directly to surface waters. In most cases, the NPDES permit program is administered by authorized states. Since its introduction in 1972, the NPDES permit program is responsible for significant improvements to our Nation's water quality. To view NPDES storm water outfalls, animal feeding operations, and waste water outfalls, visit the Missouri Department of Natural Resources Stormwater Internet Map Viewer.

Identifying Pollution Hazard Areas

Local emergency management officials should identify pollution hazard areas so that in case of a natural disaster, recovery steps will not be delayed. Pollution of public drinking water, for example, can cause severe problems with reentry and recovery. If alternate sources of safe drinking water can be identified, or relocation of water intakes can eliminate polluted drinking water, then recovery can be quicker, and local resources can be used to address other problems.

With the increases in motor vehicle registrations throughout the State, the levels of nitrocarbon emissions will naturally rise. Combinations of smog and carbon monoxide levels will also increase. In sufficient quantities, these pollutants can have deleterious effects on the health of thousands of Missourians.

For additional information on vulnerability to public health emergencies/environmental issues, see Section 3.5.18.

3.3.19 Special Events

National Special Security Events

A number of factors are taken into consideration when designating an event as a national special security event (NSSE), including the following:

- **Anticipated attendance by dignitaries**—Events that are attended by officials of the United States Government and/or foreign dignitaries may create an independent Federal interest in ensuring that the event transpires without incident and that sufficient resources are brought to bear in the event of an incident.
- **Size of the event**—A large number of attendees and participants generally increases the security requirements. In addition, larger events are more likely to draw the attention of terrorists or other criminals, particularly those interested in employing weapons of mass destruction.
- **Significance of the event**—Some events have historical, political, and/or symbolic significance that may heighten concern about possible terrorist acts or other criminal activity.

When an event is designated as an NSSE, the United States Secret Service assumes its mandated role as the lead Federal agency for the design and implementation of the operational security plan and coordinator for all Federal resources deployed to maintain the level of security needed for the designated events. The Federal Bureau of Investigation (FBI) serves as the lead agency responsible for intelligence and law enforcement operations as well as statutory Federal criminal investigations. The goal of such an operation is to prevent terrorist attacks and criminal acts.

Once an event is designated as an NSSE, the Secret Service employs existing partnerships with Federal, state, and local law enforcement and public safety officials to coordinate provision of a safe and secure environment for the event and those in attendance.

Resources used as part of past NSSE operational security plans that could be deployed for upcoming NSSE designated events include physical infrastructure security fencing and barricades, special access accreditation badges, K-9 teams, and other security technologies.

The Secret Service is responsible for planning, directing and executing Federal security operations at designated NSSE's. It also provides Federal, state, and local law enforcement partners who provide substantial, critical support to the protective mission with the necessary guidance and training regarding their role in the overall operational security plans.

The Emergency Preparedness and Response division within the U.S. Department of Homeland Security could preposition some combination of the following assets: the Domestic Emergency Support Team, Urban Search and Rescue teams, national Emergency Response Teams, the Nuclear Incident Response Team, the Strategic National Stockpile and Mobile Emergency Response System. The specific package will be tailored for each individual event based on coordination with other Federal agencies, state and local jurisdictions, available local resources, mutual aid agreements, and other event-specific requirements.

Special Events Assessment Rating

Coordinated by the Department of Homeland Security/Office of Operations Coordination and Planning (OPS), the Special Events Working Group (SEWG) is the core of an interagency process that involves over 50 Departments, agencies and components of the Federal government. Federal input and recommendations concerning Special Events are provided based on their respective authorities, responsibilities, and fields of expertise. The SEWG is co-chaired by designees from DHS Headquarters, the U.S. Secret Service, FEMA, and the FBI. The SEWG is the single forum that ensures comprehensive and coordinated Federal interagency awareness of and support to designated Special Events.

The Department of Homeland Security (DHS) Special Events Program utilizes the annual Data Call conducted in conjunction with the State, Local, Territorial and Tribal (S/L/T/T) Homeland Security Advisors. The Program provides an objective, calendared framework through which Federal, State and local entities can identify special events occurring within their jurisdictions.

The Special Events Assessment Rating (SEAR)[42] is the single Federal interagency resource used for assessing and categorizing domestic events that do not rise to the level of a National Security Special Event (NSSE). Using a risk-based approach to weigh vulnerabilities and consequences against threats, the SEWG develops the SEAR levels based primarily on event information submitted by S/L/T/T officials in the annual Data Call.

5) **SEAR-I:** Events of significant national and/or international importance that may require extensive Federal interagency security and incident management preparedness. Pre-deployment of Federal assets as well as consultation, technical advice and support to specific functional areas in which the State and local agencies may lack expertise or key resources may also be warranted. In order to ensure unified Federal support to and appropriate national situational awareness, a Federal Coordinator (FC) will be designated, and an Integrated Federal Support Plan (IFSP) (Matrix of responsibilities for all agencies involved) will be developed.
6) **SEAR II:** Significant events with national and/or international importance that may require direct national level *Federal support and situational awareness.* The magnitude and significance of these events calls for close coordination between Federal, state, and local authorities and may warrant limited pre-deployment of US Government assets as well as consultation, technical advice and support to specific functional areas in which the State and local agencies may lack expertise or key resources. In order to ensure unified Federal support to the local authorities and appropriate national situational awareness, a Federal Coordinator (FC) will be designated and an Integrated Federal Support Plan (IFSP) will be developed.
7) **SEAR-III:** Events of national and/or international importance that require only limited direct Federal support to augment local capabilities. Generally, state and local authorities adequately support these events; however, the significance of these events generally warrants national situational awareness and, depending on the jurisdiction, may require limited direct support from specific Federal agencies. In order to ensure appropriate national situational awareness, an Integrated Federal Support Plan (IFSP) may be developed.
8) **SEAR-IV:** Events with limited national importance that are generally handled at the State and local level. Unusual circumstances may sometimes necessitate the employment of specific Federal

[42] The Homeland Security Council, Planning Scenarios Executive Summaries Created for Use in National, Federal, State, and Local Homeland Security Preparedness Activities, David Howe, July 2004

resources to address unique needs of a particular event. Existing Federal assistance programs are available to state and local jurisdictions hosting the event for training, exercise, and/or tailored program support.

9) **SEAR-V:** Events that may be nationally recognized but generally have local or state importance. Federal departments and agencies will receive notice of these events for situational awareness purposes, but in most cases minimal, if any, Federal assets or resources will be expended to assist with management of these events. Federal officials will not normally actively monitor or coordinate support for these events unless specifically requested.

Description of Hazard

Significant special events may include any type of event where large groups of people are gathered together, regardless of the cause or purpose of the event, where expanded security and other resources are required above and beyond the resources typically available to local and/or state government. In such instances, event sponsors, in conjunction with local and state authorities, are responsible for coordinating the event and requesting Federal assistance, if necessary.

Special events may be motivated by political, economic or social causes, as in the case of inaugurations, state of the union addresses, and summit conferences, or by recreational causes, as with the Olympics and other major sporting events (Super Bowl, World Series, etc.). Special events may also include large holiday events such as the annual Fair St. Louis 4th of July Celebration, where large numbers of people crowd onto the Mississippi Riverfront in St. Louis.

The perception of inherent dangers and threats facing this country and Missouri has changed significantly since the terrorist attacks of September 11, 2001. In keeping with the framework of the National Response Plan, the Missouri State Emergency Operations Plan should consider special events as described herein. The following historical statistics section details some of the potential impacts on security and medical resources that a special event could have.

Anytime a large number of people are congregated in one area, an incident resulting from just about any of the hazards could have devastating impacts. For example, consider the impact a sudden, severe hailstorm could have on the population visiting the Fair St. Louis, which well over one million people usually attend each year. A hailstorm such as this struck the north St. Louis County area in April 2001, causing thousands of dollars of damage to residences and vehicles. This storm produced baseball-size (and larger) hailstones, which killed many pets and nearly all the waterfowl residing at local park ponds. An incident such as this could have devastating impacts if it were to suddenly strike the fairgrounds with over 250,000 people in attendance and without shelter. The potential impact a terrorist attack incident could impose at such an event is exponentially greater. Medical services would likely be overwhelmed with the number of injuries.

Historical Statistics

Special Security Events within Missouri

***St. Louis, Missouri, Papal Visit*[43]**

Pope John Paul II visited St. Louis, Missouri, on January 26 and 27, 1999. This pastoral visit included 30 hours of speeches, parades, prayer services, and a papal mass for about 104,000 people at the St. Louis America's Center, which filled every available seat in the center, including the Edward Jones Dome and adjoining convention exhibit hall. This mass is billed as the largest U.S. indoors gathering ever and was designated a National Special Security Event.

This two-day series of events also included a welcome address by President Bill Clinton and ceremonial farewell meeting with Vice-President Al Gore and was attended by many state officials, including Missouri Governor Mel Carnahan. Event activities were spread throughout the St. Louis metropolitan area, from the Lambert–St. Louis International Airport to the downtown area and the grounds of the Gateway Arch on the Mississippi Riverfront.

This was undoubtedly the largest single special event to occur in Missouri in recent years, with security concerns reaching to national and international levels. Close coordination between local, state, and Federal law enforcement agencies is required to provide adequate security measures for events like this. The potential for hazards from mass transportation accidents was also elevated for this event, as one quote said, "Seemingly every school bus in the region was enlisted to transport people from suburban pickup points down into St. Louis America's Center for the papal mass." Fortunately, this event was conducted without any major incidents.

***St. Louis, Missouri, World Agricultural Forum Conference*[44][45]**

The Hyatt Regency Hotel at Union Station in St. Louis hosted the World Congress meeting of the World Agricultural Forum May 18 to 20, 2003. The forum brought together agriculture industry leaders and world leaders to discuss the future of global agriculture. Mindful of Seattle's experience with violent protestors who disrupted the World Trade Organization (WTO) meeting there in December 1999, St. Louis police were braced for any possible problems that could arise from hundreds or even thousands of protestors descending on St. Louis for this event.

Four Seattle police officers were invited to St. Louis to talk about what happened at the 1999 WTO event (50,000 demonstrators overwhelmed 400 Seattle officers and protestors smashed windows and vandalized cars as police fought back with rubber bullets and tear gas). Washington, DC, police were also invited to St. Louis to share their experiences with riots during protests of major global conferences in their city.

---

[43] St. Anthony Messenger Press. 1999. "The Pope Visits St. Louis," news article in the April 1999 St. Anthony Messenger Magazine Online, available electronically at www.americancatholic.org/Messenger/Apr1999/feature1.asp.

[44] St. Louis Post Dispatch. 2003. "City police get set to deal with protestors," news article dated May 7, 2003, available electronically at www.STLtoday.com

[45] Jefferson City News Tribune. 2003. "St. Louis police will investigate officers' conduct," news article dated June 1, 2003, available electronically in the online edition at http://newstribune.com/stories/060103/sta_0601030880.asp

Although St. Louis police were not anticipating the same level or intensity of violence as in Seattle, they did have intelligence reports that some visitors would be in St. Louis who were involved in the Seattle protests and other demonstrations. Another conference, called Biodevastation 7, was scheduled immediately prior to the World Agricultural Forum (May 16 to 18, 2003) in St. Louis, which involved a gathering of opponents to genetic engineering. An organizer with the group had indicated that 200 to 800 people were expected to attend the Biodevastation 7 conference and that there would be 200 to 2,000 protestors at the World Agricultural Forum.

During this time period, in nearby Creve Coeur, Missouri, extra police were also on hand at the Monsanto property for the annual Creve Coeur Days. Monsanto, an agriculture industry leader, is a host of the annual celebration, which includes carnival rides and game booths on its property. Creve Coeur police coordinated a plan with St. Louis police to gather information about possible protests at this event.

A local international security consulting firm was in charge of security for the World Agricultural Forum conference. They worked with St. Louis police and other law enforcement agencies to prepare for possible protests at the event. Close coordination between these agencies helped to ensure that St. Louis was prepared to provide adequate security for the event and the international visitors to the city. Other than a couple of minor incidents between police and activists in the days leading up to the conference, no incidents were reported. A protest outside the conference on May 18 drew only a few hundred demonstrators, all peaceful, and only a handful of demonstrators were present during the event's two days.

St. Louis, Missouri, 2008 Vice-Presidential Debate

Washington University in St. Louis hosted the 2008 Vice-Presidential debate between candidates Sara Palin and Joe Biden on October 2 in the campus Field House. This was the third such Presidential debate that the university had hosted, making it only institution to have had three presidential debates. Though widely viewed on television and on the internet, there were still a large number of people and security concerns that the local authorities had to consider. Secret Service coordinated with the police to establish security protocols for the candidates. No breach of security was noted.

Additional Special Security Events

The following are more recent events in Missouri considered for Special Event Homeland Security (SEHS) designation requiring significant state and local resources**:**

- St. Louis, May 2004, World Agricultural Forum Regional Congress
- St. Peters, June 2004, U.S. Olympic diving trials
- Clayton, October 2004, presidential debate
- St. Louis, October 2004, Major League Baseball World Series
- St. Louis, April 2005, National Collegiate Athletic Association Division I Men's Basketball Four Tournament
- St. Louis, October 2006, Major League Baseball World Series
- Clayton, October 2008, Vice Presidential Debate

The National Security Special Events (NSSE) list shows that there have been no events of National interest within the State of Missouri.[46]

[46] http://www.secretservice.gov/nsse.shtml

Events of National Interest

Atlanta, Georgia, Centennial Olympic Park Bombing [47][48]

On Saturday July 27, 1996, Georgia Bureau of Investigation (GBI) agents in Atlanta were dispatched to the Centennial Olympic Park. About 20 minutes later, as agents were assessing the situation and continuing to attempt to steer people away from an abandoned bag, it blew up with a powerful explosion. The blast killed one visitor and injured more than 100. All of the law officers at the scene were injured except for one. A Turkish cameraman died of a heart attack while covering the explosion. FBI said of this incident, "The fatal bombing in Atlanta was a terrorist attack aimed at thousands of innocent persons gathered at the Olympic Park." This blast was the worst attack on an Olympic Games since 11 Israeli athletes were killed by Palestinian guerrillas at the 1972 games in Munich, Germany.

Chicago, Illinois, NATO 2012 Summit

The 2023 NATO Summit was held in Chicago, IL on May 20th & 21st. Originally this event was scheduled directly after the G8 Summit also to be held in Chicago, however, the Federal government announced a relocation on March 5th. Up to that point, local and state planners had prepared for the potential to have the largest number of protesters in the area. Even with the relocation of the G8 Summit the police force racked up over $14 million in costs for the event. Fortunately, no major protests or riots broke out during the summit.

Measure of Probability and Severity

Probability: Low

Severity: Low to High

Missouri will undoubtedly host future special events that will require significant security and other emergency planning considerations. The overall probability that a disastrous incident from any cause would occur in conjunction with a designated special event or special security event is considered moderate. The probability for an incident to occur during any particular special event is really a function of the hazards previously detailed in this Hazard Analysis and the probability of the independent occurrences of these hazards. However, special events will unfortunately continue to be likely targets for protests, rioting, and terrorist attacks in the United States. Refer to the measure of probability and severity discussions on the other hazards for more specific considerations.

The severity of incidents occurring in conjunction with designated special events could range from low to high, depending on many factors. The severity of these incidents will be a function of the number of people attending these events and the type and severity of the specific hazards that affect the events. Considerations of severity could range from a hoax bomb scare or terrorist threat where no one is physically injured and without any property damage to a full-scale disaster affecting a large number of people gathered at one time with mass injuries and property damage by natural, accidental, terrorist, or criminal causes. Refer to the measure of probability and severity discussions on the other hazards for more specific considerations.

---

[47] Cable News Network (CNN), Inc. 1996. "Law officers' quick thinking may have averted more tragedy," news article dated July 27, 1996, available electronically at the CNN web page: www.cnn.com/US/9607/27/park.explosion.heroes/index.html.

[48] The U.S. Department of Justice (DOJ). 1998. "Eric Rudolph Charged in Centennial Olympic Park Bombing," press release dated Wednesday October 14, 1998, available electronically at www.usdoj.gov/opa/pr/1998/October/477crm.htm

Impact of the Hazard

As with the measure of probability and severity, the potential impact of hazards occurring in association with any special event must be evaluated as a function of the specific hazard that could cause the impact on a large number of people attending any event. Refer to the impact of the hazard discussions in other hazard profiles for more hazard-specific impact considerations. Certainly, the potential impact of any hazard can be multiplied several-fold when it affects a large number of people all at once.

The information in Table 3.3.19a is from the Impact Analysis of Potential for Detrimental Impacts of Hazards done for the Emergency Management Accreditation Program.

Table 3.3.19a EMAP Impact Analysis: Special Events

Subject	Detrimental Impacts
Health and Safety of Persons in the Area at Time of Incident	May be severe for unprotected personnel and moderate to light for protected personnel in incident area.
Health and Safety of Personnel Responding to the Incident	Adverse impact expected to be severe for unprotected personnel and moderate to light for trained, equipped, and protected personnel.
Continuity of Operations	Danger to personnel in the area of the incident may require relocation of operations and lines of succession execution.
Property, Facilities, and Infrastructure	Facilities and infrastructure in the area of the incident may be denied until incident resolved.
Delivery of Services	Localized disruption of roads and/or utilities caused by incident may postpone delivery of some services.
The Environment	Localized adverse impact depending on the nature of the incident.
Economic and Financial Condition	Localized adverse impact depending on the nature of the incident.
Regulatory and Contractual Obligations	Localized adverse impact depending on the nature of the incident.
Reputation of or Confidence in the Entity	Ability to respond and recover may be questioned and challenged if planning, response, and recovery not timely and effective.

Synopsis

Adapted from the National Response Framework[49] (NRF): The perception of inherent dangers and complex threats facing this country and the potential consequences they could have on the American way of life has changed significantly since the terrorist attacks of September 11, 2001. These threats cross a broad spectrum of contingencies from acts of terrorism to natural disasters to other manmade hazards (accidental or intentional). Because all carry the potential for severe consequences, these threats must be addressed with a unified national effort. A new paradigm for incident management is required. This philosophy has been the mandate for change leading to development of the NRF.

This section has been added in keeping with the framework of the NRF. The NRF is designed as an "all-hazards/all-disciplines" plan and considers hazards under the full range of possible contingencies, including natural disasters, accidents, civil/political incidents, terrorist/criminal incidents, and significant events/designated special events.

[49] http://www.fema.gov/national-response-framework

Significant special events are any type of event where large groups of people are gathered and expanded security and other resources are required above and beyond the resources typically available to local or state government. Special events may be motivated by political, economic, or social causes, as in the case of inaugurations, state of the union addresses, and summit conferences, or they may be motivated by recreational causes as with major sporting events or designated holiday events.

Regardless of the purpose or cause, special events will place a large number of people in one area at one time. Anytime people are crowded together in one place, an incident resulting from just about any of the hazards could have compounded and devastating impacts.

In such instances, event sponsors, in conjunction with local and state authorities, are responsible for coordinating the event and requesting assistance at the Federal level, if necessary. Local and state authorities are responsible for coordinating requirements from the organization sponsoring an event and determining resource shortfalls and submitting resource requests, through the existing structures and mechanisms, to the national level for consideration. Event sponsors are responsible for developing concepts for conducting the event, identifying resource requirements necessary to support the event, and submitting resource requests to local and state governments for consideration.

For additional information on vulnerability for special events, see Section 3.5.19.

3.3.20 Terrorism

Description of Hazard

Terrorism, as defined by the Federal Bureau of Investigation (FBI) is, "the unlawful use of force or violence against persons or property to intimidate or coerce a government, the civilian population, or any segment thereof, in furtherance of political or social objectives." [50]The effects of terrorism can vary significantly, including loss of life, injuries to people and properties, and disruptions in services (e.g., water supplies, public transportation, and communications).

According to the FBI, there are two primary types of terrorism[51]:

- **Domestic Terrorism** involves groups or individuals whose terrorist activities are directed at elements of US local, state or federal government or populations without foreign direction.
- **International Terrorism** involves terrorist activity committed by nations, groups or individuals who are foreign-based and/or directed by countries or groups outside the United States or whose activities transcend national boundaries.

Forms of Terrorism[52]

Terrorism can take place in various forms, depending on the technological means available to the terrorist group, the nature of the issue motivating the attack, and the points of weakness of their target. Potential terrorist actions include the following:

- **Bombings**—Bombings have long been used in terrorist attacks and probably represent the most "traditional" form of terrorism. These types of incidents range from small-scale letter bombs to large-scale attacks on specific buildings. Other bomb-related incidents frequently involve "suicide bombers," who believe that by using themselves as the delivery and detonation method of a bomb attack they demonstrate their dedication to an ideology.
- **Airline Attacks**—In the past, terrorist acts involving aircrafts were generally limited to hijackings and bombings. However, the attacks on the World Trade Center buildings in New York City and the pentagon in 2001 brought a new avenue to light—the use of commercial aircrafts to attack infrastructure targets. Foreign surface-to-air missile attacks also present a threat to U.S. aircrafts.
- **Weapons of Mass Destruction (WMD) Attacks**—WMD attacks usually involve nuclear weapons or biological or chemical agents. Chemical and biological agents are infectious microbes or toxins used to produce illness or death. They can be dispersed as aerosols or airborne particles directly onto a population, producing an immediate effect (a few seconds to a few minutes) or a delayed effect (several hours to several days). Severity of injuries depends on the type and amount of the agent used and duration of exposure. Because some biological agents take time to grow and cause disease, an attack using this type of agent may go unnoticed for several days. Though less likely, a nuclear event has the potential to cause immense damage to infrastructure and cause large numbers of casualties. Even a small event such as an Improvised Nuclear Device (IND) explosion has the ability to destroy cities and cause the immediate and delayed death of 100,000 people.

[50] http://www.nij.gov/topics/crime/terrorism/welcome.htm
[51] Terms and definitions in this section were established in the Missouri Hazard Mitigation Plan 2010 Update.
[52] Events listed in this section are referenced in the Missouri Hazard Mitigation Plan 2010 Update.

- **Infrastructure Attacks**—These types of attacks can impact various potential targets, including water distribution systems and treatment plants, utility companies and services, emergency services, gas and oil production facilities, telecommunications centers, transportation terminals, media facilities, government buildings, and religious institutions. The goal is to disrupt of remove critical services to the populace that is dependent upon them. Though the loss of life usually is limited, infrastructure attacks can have a wider direct effect on the populace.
- **Cyberterrorism**—Cyberterrorism pertains to attacks on computer-based systems that are designed to spread disinformation and propaganda, deny service to legitimate computer users, spread electronic viruses to corrupt vital data, or cause critical infrastructure outages. Political conflicts that have led to attacks on cyber systems include clashes between India and Pakistan, Israel and the Palestinians, the North Atlantic Treaty Organization, and Serbia.
- **Agroterrorism**—Agroterrorism involves intentional contamination of commercial produce or meat supplies. Because the United States supplies approximately 16 percent of the world's meat, 40 percent of its soybeans, and 41 percent of its corn, a deadly fungus or bacteria could be devastating. Of the 222 possible bioterrorism attacks that have occurred worldwide in the twentieth century, only 17 of these targeted commercial livestock or plants, according to the Institute for National Strategic Studies.
- **Arson**—Intentional fires have caused extensive damage during terrorist-related incidents in the past. These types of incidents may also be associated with bombings and usually target specific structures, such as churches. Although deliberately set fires have been reported at 15 churches in Missouri, none have been determined to be hate crime-related or terrorist-related incidents.
- **Kidnappings/Assassinations**—Kidnappings and assassinations may also be terrorist-related incidents, but because these events generally involve few individuals, their effect on emergency management operations may be minimal in terms of response.

Domestic Terrorism

According to the FBI, domestic groups with actual or potential terrorist intent represent interests that span the full spectrum of political and economic viewpoints, as well as social issues and concerns. The current domestic terrorist threat comes primarily from white supremacists, black separatists, animal rights/environmental terrorists, anarchists, antiabortion extremists, and self-styled militia.

- **White Supremacists or Right-Wing Terrorists**—Right-wing terrorist groups often adhere to the principles of racial supremacy and embrace antigovernment, antiregulatory beliefs. Generally, extremist right-wing groups engage in activities that are protected by constitutional guarantees of free speech and assembly. Examples of this type of group include Aryan Nations, the Order, and Posse Comitatus. Missouri has seen some activity from these groups in the past few years. According to the Southern Poverty Law Center, Missouri has two extremist groups operating within its borders. Although a state statute against paramilitary training exists, one of these groups is also known to have such a facility in Missouri. In addition, several special gatherings of extremist groups have taken place within the State in recent years.
- **Black Separatists**—United States-based black separatist groups follow radical variants of Islam and in some cases express solidarity with al-Qa'ida and other international terrorist groups.
- **Animal Rights and Environmental Terrorists**—Operating under the umbrella of the Animal Liberation Front and Earth Liberation Front, these terrorists use a variety of tactics against their targets, including arson, sabotage/vandalism, theft of research animals, and the occasional use of explosive devises

- **Anarchists**—The potential for violence by anarchists and other emerging revolutionary groups, such as the Anarchist Black Cross Federation (ABCF), will continue to be an issue for law enforcement. The stated goals of the ABCF are "the abolishment of prisons, the system of laws, and the capitalist state." The ABCF believes in armed resistance to achieve a stateless and classless society. The ABCF has continued to organize, recruit, and train anarchists in the use of firearms.
- **Anti-abortion Extremists**—The FBI has investigated anti-abortion groups with potential violent anti-abortion extremists views and are linked to terrorism ideologies or groups that pose a current threat.

International Terrorism

The United States continues to face an ongoing challenge from international terrorism. In general terms, the international terrorist threat can be divided into three categories: loosely affiliated extremists operating under the radical jihad movement, formal terrorist organizations, and state sponsors of terrorism. Each of these categories, which represent threats to U.S. citizens and interests both abroad and at home, are described below:

- **Loosely Affiliated Extremists** — These are motivated by political or religious beliefs, and pose the most urgent threat to the United States.
- **Formal Terrorist Organizations** — These organizations are typically autonomous and have their own infrastructures, personnel, financial arrangements, and training facilities.
- **State Sponsors of Terrorism** — This category includes countries known to sponsor terrorism and to view it as a tool of foreign policy. Currently, the U.S. Department of state recognizes four countries in this category: Iran, Sudan, Syria, and Cuba. [53]

Foreign Terrorist Organizations (FTOs) are foreign organizations that are designated by the secretary of state in accordance with Section 219 of the Immigration and Nationality Act, as amended by the Antiterrorism and Effective Death Penalty Act of 1996. A list is compiled every two years. The current list of FTOs[54], released in September 2012, designates the following organizations:

Table 3.3.20a EMAP Impact Analysis: Special Events

Designated Foreign Terrorist Organizations	
Date Designated	**Name**
5/30/2012	Abdallah Azzam Brigades (AAB)
10/8/1997	Abu Nidal Organization (ANO)
10/8/1997	Abu Sayyaf Group (ASG)
3/27/2002	Al-Aqsa Martyrs Brigade (AAMB)
10/8/1999	al-Qa'ida (AQ)
12/17/2004	al-Qaida in Iraq (AQI)
1/19/2010	al-Qa'ida in the Arabian Peninsula (AQAP)
3/27/2002	al-Qaida in the Islamic Maghreb (AQIM)

[53] http://www.state.gov/j/ct/list/c14151.htm
[54] http://www.state.gov/j/ct/rls/other/des/123085.htm

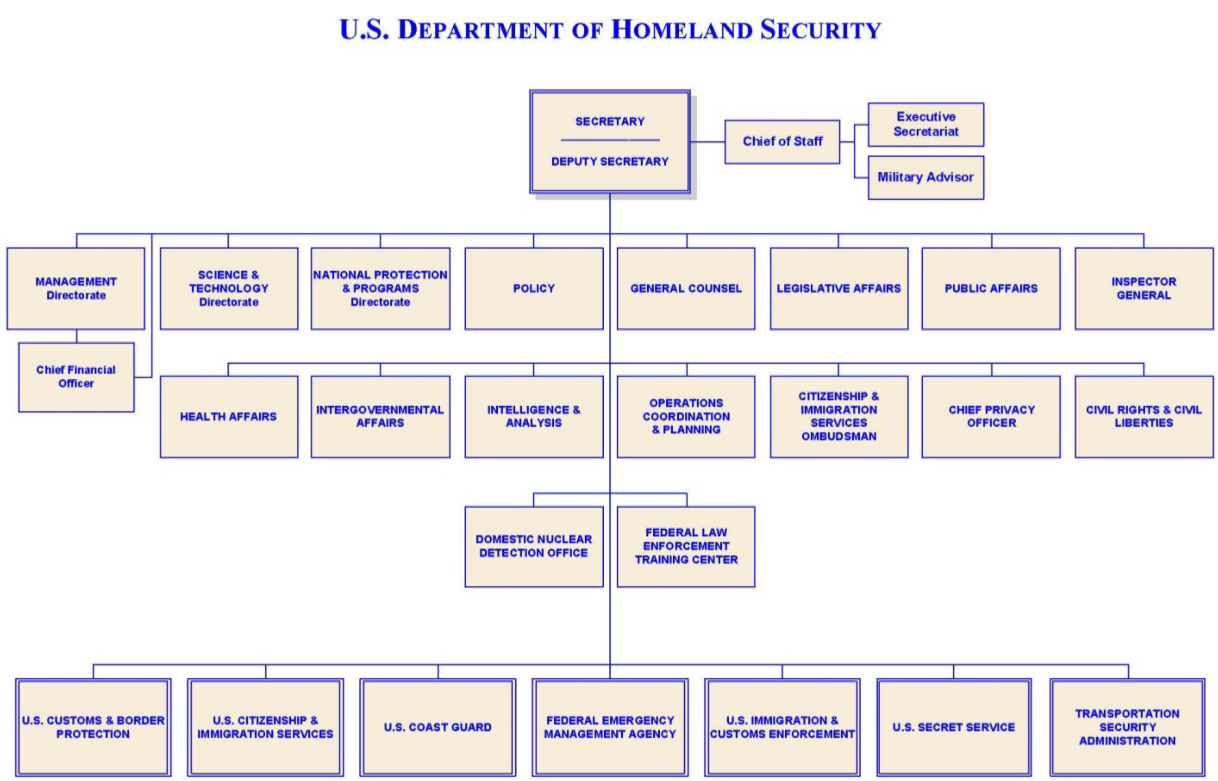
Designated Foreign Terrorist Organizations	
3/18/2008	al-Shabaab
3/22/2004	Ansar al-Islam (AAI)
5/23/2011	Army of Islam (AOI)
3/27/2002	Asbat al-Ansar (AAA)
10/8/1997	Aum Shinrikyo (AUM)
10/8/1997	Basque Fatherland and Liberty (ETA)
8/9/2002	Communist Party of the Philippines/New People's Army (CPP/NPA)
7/13/2004	Continuity Irish Republican Army (CIRA)
10/8/1997	Gama'a al-Islamiyya (Islamic Group) (IG)
10/8/1997	HAMAS
9/19/2012	Haqqani Network (HQN)
8/6/2010	Harakat ul-Jihad-i-Islami (HUJI)
3/5/2008	Harakat ul-Jihad-i-Islami/Bangladesh (HUJI-B)
10/8/1997	Harakat ul-Mujahidin (HUM)
10/8/1997	Hizballah
9/19/2011	Indian Mujahedeen (IM)
6/17/2005	Islamic Jihad Union (IJU)
9/25/2000	Islamic Movement of Uzbekistan (IMU)
12/26/2001	Jaish-e-Mohammed (JEM)
3/13/2012	Jemaah Anshorut Tauhid (JAT)
10/23/2002	Jemaah Islamiya (JI)
11/4/2010	Jundallah
10/8/1997	Kahane Chai (Kach)
7/2/2009	Kata'ib Hizballah (KH)
10/8/1997	Kurdistan Workers Party (PKK) (Kongra-Gel)
1/30/2003	Lashkar i Jhangvi (LJ)
12/26/2001	Lashkar-e Tayyiba (LeT)
10/8/1997	Liberation Tigers of Tamil Eelam (LTTE)
12/17/2004	Libyan Islamic Fighting Group (LIFG)
10/11/2005	Moroccan Islamic Combatant Group (GICM)
10/8/1997	National Liberation Army (ELN)
10/8/1997	Palestine Liberation Front (PLF)
10/8/1997	Palestinian Islamic Jihad (PIJ)
10/8/1997	PFLP-General Command (PFLP-GC)
10/8/1997	Popular Front for the Liberation of Palestine (PFLF)
5/16/2001	Real Irish Republican Army (RIRA)
10/8/1997	Revolutionary Armed Forces of Colombia (FARC)
10/8/1997	Revolutionary Organization 17 November (17N)
10/8/1997	Revolutionary People's Liberation Party/Front (DHKP/C)
5/18/2009	Revolutionary Struggle (RS)

Designated Foreign Terrorist Organizations	
10/8/1997	Shining Path (SL)
9/1/2010	Tehrik-e Taliban Pakistan (TTP)
9/10/2001	United Self Defense Forces of Colombia (AUC)

Government Authority

After the attacks on September 11, 2001, parts of 22 domestic agencies were consolidated into one department, the U.S. Department of Homeland Security (DHS), to protect the nation against future terrorist threats. Roles of those agencies include analyzing threats and intelligence, guarding national borders and airports, protecting critical infrastructure, and coordinating response efforts for future emergencies. Many feel the creation of DHS is the most significant transformation of the U.S. government in the last 50 years. The current organization, as of April 1, 2012, of DHS is illustrated below.

Figure 3.3.20.1 - DHS Organization[55]



The FBI is the lead federal agency for investigating terrorism. The FBI is authorized to open an investigation whenever, “facts or circumstances reasonably indicate that two or more persons are engaged in an enterprise for the purpose of furthering political or social goals wholly or in part through

55 http://www.dhs.gov/xlibrary/assets/dhs-orgchart.pdf

activities that involve force or violence and a violation of the criminal laws of the United States." In any given year, the FBI engages in approximately 24 full-scale domestic terrorism investigations. The FBI maintains a state-of-the-art computer database known as the Terrorist Information System, which contains information on known or suspected terrorist groups and individuals. The system contains information on over 200,000 individuals and over 3,000 organizations.

An essential weapon in the battle against terrorists is the Joint Terrorism Task Force (JTTF)[56]. A national JTTF, located at FBI Headquarters, includes representatives from the U.S. Department of Defense, U.S. Department of Energy, FEMA, Central Intelligence Agency, Customs Service, Secret Service, and the Immigration and Naturalization Service. Additionally, there are 66 local JTTFs where representatives from federal agencies, state and local law enforcement personnel, and first responders work together to track down terrorists and prevent acts of terrorism in the United States. There are two JTTFs in Missouri, one in Kansas City and one in St. Louis.

After terrorist-related events, communities may receive assistance from state and federal agencies operating within the existing Integrated Emergency Management System. FEMA is the lead federal agency for supporting state and local response to the consequences of terrorist attacks.

Historical Statistics[57]

The following section highlights noteworthy terrorist-related threats and actual attacks that have occurred in the United States since 1970. The French Revolution provided the first uses of the words "Terrorist" and "Terrorism." Use of the word "terrorism" began in 1795 in reference to the Reign of Terror initiated by the Revolutionary government. The agents of the Committee of Public Safety and the National Convention that enforced the policies of "The Terror" were referred to as "Terrorists." The French Revolution provided an example to future states in oppressing their populations. It also inspired a reaction by royalists and other opponents of the Revolution who employed terrorist tactics such as assassination and intimidation in resistance to the Revolutionary agents. The Parisian mobs played a critical role at key points before, during, and after the Revolution. The following section highlights noteworthy terrorist-related threats and actual attacks that have occurred in the United States since 1970.

In 1972, members of a U.S. fascist group called Order of the Rising Sun were found in possession of 30 to 40 kilograms of typhoid bacteria cultures, which they planned to use to contaminate water supplies in Chicago, St. Louis, and other large Midwestern cities.

In 1984, two members of an Oregon cult headed by Bhagwan Shree Rajneesh cultivated Salmonella bacteria and used it to contaminate restaurant salad bars in an attempt to affect the outcome of a local election. Although approximately 751 people became ill and 45 were hospitalized, there were no fatalities.

In February 1993, an improvised bomb exploded in a rental van parked on the second level of the World Trade Center's parking basement. The bomb contained approximately 1,200 to 1,500 pounds of a homemade fertilizer-based explosive, urea nitrate. The blast produced a crater 150 feet in diameter and

[56] http://www.fbi.gov/about-us/investigate/terrorism/terrorism_jttfs
[57] Historical information and statistics in this section can be referenced in the Missouri Hazard Mitigation Plan 2010 Update.

five floors deep. Although the motive for the attack was never confirmed, it is believed that the suspect who masterminded the bombing was either backed by a loose network of militant Muslims or directed by Iraq. The incident, which killed 6 people and injured more than 1,000, was the most significant international terrorist act that had ever been committed on U.S. soil at that time.

In April 1995, a massive bomb exploded inside a rental truck parked near the Murrah Federal Building in Oklahoma City, destroying half the nine-story building and killing 168 people. The incident was traced to Timothy McVeigh, who was convicted of the bombing and executed by lethal injection in June 2001. He was the first federal prisoner to be executed in 38 years. McVeigh was a survivalist who believed individual rights (e.g., gun control) were being deprived by government agencies. Consequently, he was convinced he acted to defend the Constitution and saw himself as a crusader and hero. This was the worst terrorist event, either domestic or international in origin that had ever occurred in the United States at that time.

In March 1995, four members of the Minnesota Patriots Council, a right-wing militia organization advocating the violent overthrow of the U.S. government, were convicted of conspiracy charges under the Biological Weapons Anti-Terrorism Act of 1989 for planning to use ricin, a lethal biological toxin. The four men allegedly conspired to assassinate federal agents who served papers on one of them for tax violations.

In May 1995, a member of the neo-Nazi organization Aryan Nations was arrested in Ohio on charges of mail fraud. He allegedly misrepresented himself when ordering three vials of freeze-dried Yersinia Pestis, the bacteria that causes bubonic plague, from a Maryland biological laboratory.

In October 1995, the Amtrak Sunset Limited passenger train derailed near Hyder, Arizona. It was determined that the train track had been sabotaged, causing the train to derail and topple 30 feet from a bridge. A letter signed by the Sons of Gestapo was left at the scene. One person was killed and 83 others were injured in this incident.

In November 1995, members of the Tri-States Militia (a group composed of militia from at least 30 states) were arrested after being linked to five would-be terrorists whose bomb plots were thwarted by federal and state law enforcement agencies. The plots involved blowing up the Southern Poverty Law Center, offices of the Anti-Defamation League, federal buildings, abortion clinics, and gay community locations.

In December 1995, an Arkansas man was charged with possession of ricin in violation of the Biological Weapons Anti-Terrorism Act. The man was arrested and subsequently hanged himself in his jail cell the next day.

In July 1996, a pipe bomb exploded in Atlanta’s Centennial Olympic Park as the city was hosting the summer Olympic Games. One person was killed and dozens were wounded. It was later determined that the bomb had been planted by Eric Robert Rudolph, who was also suspected of being responsible for a double bombing at the Sandy Springs Professional Building in Atlanta in January 1997 and a double bombing at the Otherside Lounge in Atlanta in February 1997. Rudolph was arrested in May 2003 after five years on the run. He is a former soldier and survivalist with extreme right-wing views and is also reported to have ties to white supremacist groups.

On September 11, 2001 there were a series of coordinated terrorist suicide attacks by Islamic extremists upon the United States of America. Nineteen terrorists (see link) affiliated with al-Qaeda hijacked four commercial passenger jet airliners. Each team of hijackers included a trained pilot. The hijackers intentionally crashed two of the airliners (United Airlines Flight 175 and American Airlines Flight 11) into the World Trade Center in New York City, one plane into each tower (1 WTC and 2 WTC), resulting in the collapse of both buildings soon afterward and extensive damage to nearby buildings. The hijackers crashed a third airliner (American Airlines Flight 77) into the Pentagon in Arlington County, Virginia, near Washington, D.C. Passengers and members of the flight crew on the fourth aircraft (United Airlines Flight 93) attempted to retake control of their plane from the hijackers; that plane crashed into a field near the town of Shanksville in rural Somerset County, Pennsylvania. In addition to the 19 hijackers, 2,974 people died as an immediate result of the attacks, and the death of at least one person from lung disease was ruled by a medical examiner to be a result of exposure to WTC dust. Another 24 people are missing and presumed dead. The victims were predominantly civilians. The New York City Fire Department lost 341 New York City Fire Department firefighters and 2 paramedics, while 23 New York Police Department, 37 Port Authority Police Department officers, and 8 private ambulance personnel were killed. There were 125 victims in the Pentagon. The dead included 8 children. The youngest victim was a 2 year-old child on Flight 175, the oldest an 82 year-old passenger on Flight 11. According to the Associated Press, the city identified over 1,600 bodies but was unable to identify the rest (about 1,100 people). They report that the city has "about 10,000 unidentified bone and tissue fragments that cannot be matched to the list of the dead." Bone fragments were still being found in 2006 as workers prepared the damaged Deutsche Bank Building for demolition. The average age of all the dead in New York City was 40.

The attacks created widespread confusion across the United States. All international civilian air traffic was banned from landing on US soil for three days; aircraft already in flight were either turned back or redirected to airports in Canada or Mexico. Unconfirmed and often contradictory reports were aired and published throughout the day. One of the most prevalent of these reported that a car bomb had been detonated at the U.S. State Department's headquarters, the Truman Building in Foggy Bottom, Washington, D.C.

Between early October and early December 2001, five people died from anthrax infection, and at least 13 others contracted the disease in Washington, DC; New York City; Trenton, New Jersey; and Boca Raton, Florida. Anthrax spores were found in a number of government buildings and postal facilities in these and other areas. Most of the confirmed anthrax cases were tied to contaminated letters mailed to media personalities and U.S. senators. Thousands of people were potentially exposed to the spores and took preventive antibiotics. Numerous mail facilities and government buildings were shut down for investigation and decontamination.

In the wake of these incidents, federal, state, and local emergency response agencies across the United States responded to thousands of calls to investigate suspicious packages, unknown powders, and other suspected exposures. Almost all of the incidents turned out to involve no actual biohazard. Nevertheless, emergency responders typically treated each call as a potentially serious health and safety risk. During this tense time, in Missouri, the Department of Health and Senior Services (DHSS) issued numerous health alert advisories to local officials and the public, providing guidance on how to handle anthrax or suspicious letters and packages during a time of extremely heightened tensions. DHSS also instituted a surveillance system, contacting health providers to obtain public health information twice

weekly, while also working to improve the public health infrastructure, information sharing, health communication networks, and hospital surge capabilities.

On October 2nd, 2002, a month long sniper spree terrorized the entire Washington DC area as a sniper duo gunned down 10 people at random. It ended when the law enforcement team lead by the Montgomery County SWAT, supported by the FBI and the State Police, arrested the shooters at a truck stop while sleeping in their modified vehicle. The car had been altered by the snipers to accommodate the ability to get into the truck and shoot through a hole without having to leave the vehicle. Their targets were random and varied in age and gender. They struck in both Maryland and Virginia.

In 2005, the FBI arrested 11 people in relation to 17 attacks that included the $12 million arson of the Vail Ski Resort in Vail, Colorado, in 1998, the sabotage of a high-tension power line near Bend, Oregon, in 1999 and other more recent attacks. The FBI, ATF and other federal agencies consolidated their investigations to focus the effort on bringing charges. Measure of Probability and Severity

Measure of Probability and Severity

Probability: Low
Severity: Low to High

The threat of terrorism in the United States remains a concern. Over the past few years, acts or suspected acts of terrorism committed against the United States has remained steady with increases and decreases as new measures are put into place and terrorist continue the ongoing battle of overcoming those measures.. According to the FBI, two known or suspected terrorist acts were recorded in the United States in 1995, 3 in 1996, 4 in 1997, 5 in 1998, and 12 in 1999. In addition to the 12 acts in 1999, an additional 7 planned acts of terrorism were prevented in the United States. There have been many attempts of terrorism in the turn of the century; however, due to new laws and efforts focused on identifying, tracking, and arresting those threats, most have been stopped. More recently the focus has been on Cyber Terrorism as the attacks have been increasing and more vulnerability are identified and addressed.

Although several different extremist groups have been identified in Missouri, there have been no indications of any specific recent terrorist activities in the state. The potential does remain, however, for new extremist and/or terrorist groups to move into the State at any time. As such vigilance on behalf of the state is important, as it would take longer to develop a defense against a new threat than it would be for new threats to evolve.

An open society such as ours remains a potential target for terrorists. Large cities with a variety of news media outlets represent more likely locations for terrorist acts, due to the general desire of terrorists to want their acts to reverberate in the news media and reach the largest audience possible. Since Missouri does not have large media markets compared to some states, it is not as likely a target for terrorist activity as those other states. However, the Oklahoma City bombing debunked the idea that rural America is completely safe from terrorists.

With this in mind, it appears that a terrorist attack is possible in Missouri; the probability of such an attack is moderate. This is a change from low probability that was noted in the 2004 plan, but the HMPT concurred during a planning team meeting that the probability should be raised to moderate. This

probability is not based just on historical incidents in Missouri, but takes into account that the nation has been on a high or elevated threat level since 2001, as discussed in the following paragraphs.

Because of the potential for future terrorist-related incidents, a National Terrorism Advisory System[58] was developed to disseminate timely, detailed information regarding the heightened risk of terrorist acts to federal, state, and local governments and to the American people. This system will issue an alert only when credible information is available to determine a heightened risk of attack. NTAS will issue an Elevated Threat Alert if there is a credible terrorist threat and an Imminent Threat Alert if there is a credible, specific and impending terrorist threat. Threat Alerts are issued by the secretary of Homeland Security in consultation with the attorney general and other appropriate federal agency heads, including other members of the Homeland Security Council.

Should Missouri experience a terrorist attack, the severity of such an attack could range from high to low depending on the attack. For instance, if a building was blown up and no casualties occurred, as long as it was not a critical facility, the severity of the attack would be low. However, if a terrorist group decided to contaminate a large urban area's water supply with a poisonous chemical, the severity of the attack could be very high due to the number of people directly affected by the poisoned water, as well as damage to that community's sense of well-being. An attack of this nature could potentially result in mass hysteria and instability concerning the government's ability to protect its citizens.

Local communities are focused and engage in Missouri's Homeland Security Program through the establishment of regional advisory groups, called Regional Homeland Security Oversight Committees (RHSOCs). RHSOCs fall under the governance structure of the Homeland Security Advisory Council. Missouri's program is focused on establishing a common sense, logical governance structure and process to facilitate homeland security related decisions consistently across the State. There are currently several initiatives underway. They include: the Missouri Emergency Resource Information Portal (ERIP)[59] designed to assist with incident management, resource tacking, communications and asset request processing; the Missouri Public Private Partnership Working Group (MOP3)[60] which is involved with fostering the involvement if the private sector to augment and support Missouri's prioritized homeland security issues and initiatives; The Homeland Security K-12 Safe Schools Working Group[61] which assists with pandemic planning for schools; the Higher Education Working Group[62], the Homeland Security Mapping and Geospatial initiative[63], the Missouri Homeland Security Alert Network[64], the Governor's Faith-Based and Community Service Partnership for Disaster Recovery[65], the Missouri Emergency Resource Registry[66], and the American Red Cross Ready Rating[67] program.

Impact of the Hazard

As stated above, terrorist acts could potentially undermine the confidence that people have in their own security and in their government's ability to protect them from harm. For example, instructions to make

[58] http://www.dhs.gov/xlibrary/assets/ntas/ntas-public-guide.pdf
[59] https://erip.dps.mo.gov/
[60] http://www.dps.mo.gov/dir/programs/ohs/initiatives/mop3/
[61] http://moces.org/index.php
[62] http://campussecurity.missouri.org/
[63] http://www.dps.mo.gov/dir/programs/ohs/initiatives/gis/
[64] http://www.dps.mo.gov/dir/programs/ohs/initiatives/moalert/default.asp?h=0
[65] http://www.sema.dps.mo.gov/programs/gfbcspdr.asp
[66] http://www.dps.mo.gov/dir/programs/ohs/initiatives/mop3/merr.asp
[67] http://readyrating.org/

bombs are readily accessible to potential terrorists (including via the Internet), and the materials for their construction are readily available. Because bombs can be made so easily, the threat of a bomb should not be taken lightly. The threat of a bomb can disrupt a community almost as effectively as an actual bomb, while creating far fewer risks for the persons making the threat. Therefore, no matter how large or small the incident, a terrorist act can potentially have a major impact on a community.

The information below is from the Impact Analysis of Potential for Detrimental Impacts of Hazards done for the Emergency Management Accreditation Program.

Table 3.3.20a EMAP Impact Analysis: Terrorism

Subject	Detrimental Impacts
Health and Safety of Persons in the Area at Time of Incident	Adverse impact expected to be severe for unprotected personnel and moderate to light for protected personnel.
Health and Safety of Personnel Responding to the Incident	Adverse impact expected to be severe for unprotected personnel and moderate to light for trained and protected personnel.
Continuity of Operations	Damage to facilities/personnel in the area of the incident may require relocation of operations and lines of succession execution.
Property, Facilities, and Infrastructure	Facilities and infrastructure in the area of the incident may be extensive for explosion, moderate to light for HazMat.
Delivery of Services	Disruption of lines of communication and destruction of facilities may extensively postpone delivery of services.
The Environment	May cause extensive damage, creating denial or delays in the use of some areas. Remediation needed.
Economic and Financial Condition	Local economy and finances adversely affected, possibly for an extended period of time, depending on damage and length of investigation.
Regulatory and Contractual Obligations	Regulatory waivers may be needed. Fulfillment of contracts may be difficult. Demands may overload ability to deliver.
Reputation of or Confidence in the Entity	Ability to respond and recover may be questioned and challenged if planning, response, and recovery not timely and effective.

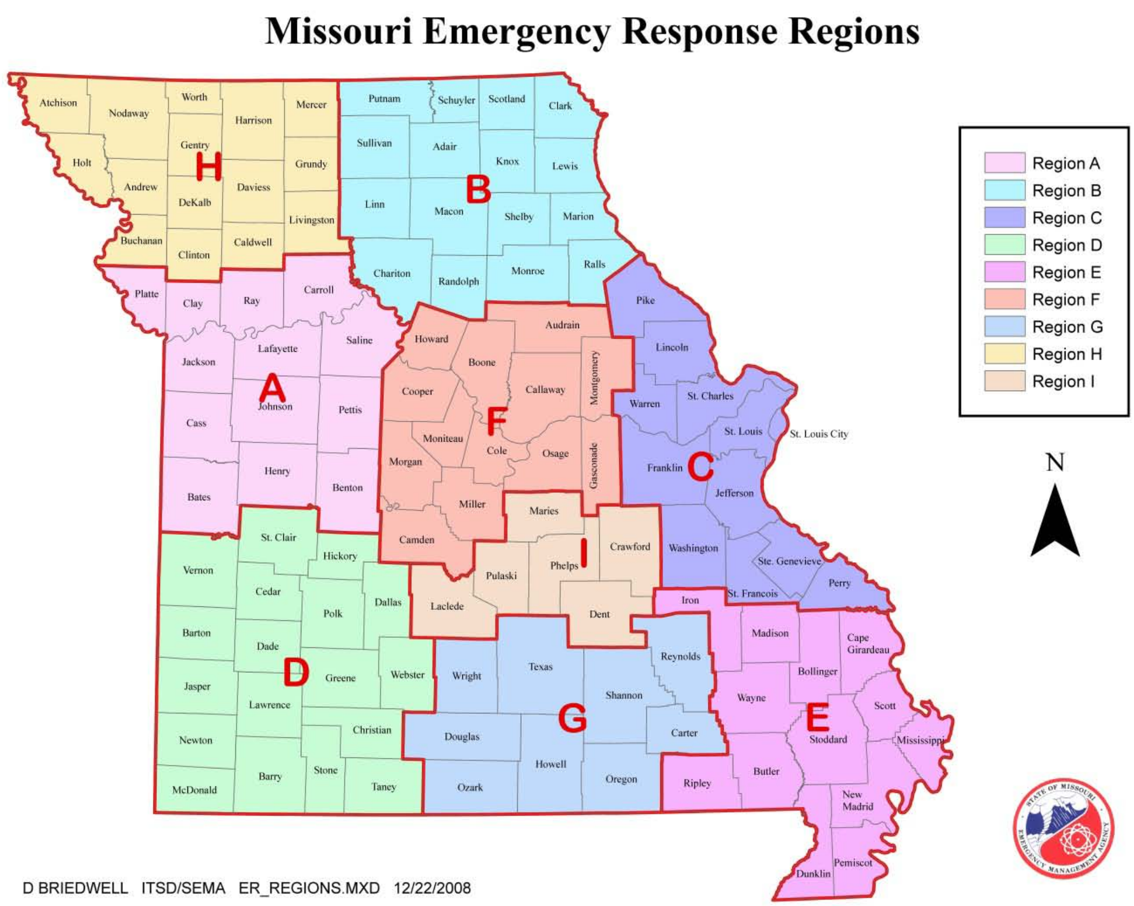
Synopsis

A trend toward high-profile, high-impact attacks has corresponded with growing concerns over the potential use of weapons of mass destruction (WMD). Between 1997 and 2000, the FBI investigated 779 WMD-related reports, generally involving individuals or small groups. The vast majority of these cases were found to be false or fabricated reports. The biological toxin ricin and the bacterial agent anthrax are emerging as the most prevalent agents involved in those investigations. In 2000, 90 of 115 biological threats investigated by the FBI involved threatened use of anthrax. Given the potential for inflicting large-scale injury or death, the efforts of international and domestic terrorists to acquire WMDs remain a significant concern and priority of the FBI as well as other US agencies.

To improve and assist in the homeland security efforts, Former Governor Blunt signed an executive order formalizing the merger of homeland security responsibilities into the Department of Public Safety. To assist in addressing the rising terror threats, Current Missouri Governor Jay Nixon named Jerry Lee to be director of the Department of Public Safety on Oct 18, 2011. Mr. Lee chairs a 17-member council made up of directors from other state departments and agencies. These include the State Emergency Management Agency, Department of Health and Senior Services, Department of Transportation, Department of Agriculture, Department of Natural Resources, Department of Economic Development, Missouri State Highway Patrol, Missouri State Water Patrol, Missouri National Guard, Missouri State Fire Marshall, Missouri State Public Service Commission, chief information officer of the State, and three members appointed by the governor. This council ensures that proper homeland security plans are in place at local and state levels while also examining how homeland security grant funds can best be coordinated and expedited.

The SEMA Emergency Response Regions Map (Figure 3.3.20.2) indicates locations of 9 Response Regions for Missouri. A few of these regions include hazardous materials response teams with enhanced capabilities for response to WMD incidents, including incidents involving nuclear or radiological materials and biological and chemical agents. The SEMA Terrorism Program should be contacted to fully determine the capabilities of the Homeland Security Response Teams in specific areas.

Figure 3.3.20.2 - Missouri's Emergency Response Regions



Source: State Emergency Management Agency:
http://www.sema.dps.mo.gov/programs/area_coordinator.asp

For additional information on vulnerability to terrorism, see Section 3.3.20.

3.3.21 Utilities (Interruptions and System Failures)

Description of Hazard

Utility interruptions and failures may involve electrical power, natural gas, public water, and communications systems. All of these systems or combinations of these utility systems exist virtually throughout the State. Many utilities are localized and serve only one community, while other utilities serve a regional area. Utilities are often dispersed over a wide area, and many have facilities located throughout their service area. For example, many electric companies have multiple generating facilities, which can redistribute power via transmission lines as they are connected to load stations. Therefore, power can be redistributed, if needed, so that power is lost to as limited an area as possible. Many water companies have some type of back-up systems such as water impoundments, other deep wells, or hook-up arrangements with other water companies. Similar switching and rerouting capabilities may exist with communications and natural gas utilities. Utility systems exist everywhere and are subject to damage from digging, fire, traffic accidents, geomagnetic storms, and severe weather, including flooding and other day-to-day events. Many utilities use emergency batteries or generators to provide back-up power for high priority equipment.

Historical Statistics

Because utilities exist everywhere in the State, damage to utilities may occur frequently. This may be due to a backhoe cutting a buried line, an accident involving a motor vehicle, a flood, geomagnetic storms, or other severe weather. Many of these interruptions or failures go unreported to the Public Service Commission (PSC), and no definitive reporting system exists. Therefore, limited statistical information is available.

On March 13, 1989 a geomagnetic storm caused the Hydro-Québec power grid to fail. On March 10, an explosion on the sun released a billion-ton cloud of gas that headed towards earth at a million miles per hour. The solar flare that followed the explosion caused short-wave radio interference immediately. The magnetic disturbance was so intense that it created electrical currents in the ground beneath North America. These currents found a weakness in the Québec power grid and millions of people were without power for 12 hours. The power outage closed schools and businesses, closed Dorval Airport, and shut down the Montreal Metro during morning rush hour. U.S. electrical utilities were also affected. 96 electrical utilities in New England were interrupted while other reserves of electrical power were brought online. Across the United States, over 200 power grid problems were reported within minutes of the storm but none caused a blackout (NASA, 2009).

During the flood of 1993, telecommunications companies proved their adaptability by using cellular service to replace wire line service in areas where service could not be restored in a timely manner. One local exchange company (LEC) used a trailer with cellular pay phones where the land lines were interrupted. Another company temporarily replaced analog subscriber carrier service with site-based cellular service. Short-haul portable microwave was also used to replace copper lines lost during the flood.

On January 30, 2002, a severe ice storm struck portions of western and northern Missouri, leaving devastation and darkened homes and businesses. Many news articles referred to this ice storm as the worst in Missouri's history. During the ice storm, ice accumulated on any object that was at or below freezing, and the weight of the ice broke utility poles, conductors, tree limbs, and other objects that could not withstand the weight of the ice. Ice accumulations over an inch were reported in many areas.

Many tree branches could not withstand the added weight of the ice and fell to the ground, striking whatever was in their path. Cars, homes, streets, properties, and electric power facilities were recipients of the falling trees and limbs. When the ice began to melt, the falling ice caused additional outages. Some electric customers experienced outages more than once during that period, as power was restored but interrupted again by falling limbs.

At the peak of outages, over 400,000 customers were without power. Within three days, most of these customers were returned to service, but many customers in more heavily damaged areas were without power for over a week. Utilities affected by the ice storm quickly mobilized all of their available crews and sought outside assistance. Work crews from 16 different states came to western Missouri in an effort to rapidly restore power to as many customers as possible.

On July 19 and 20, 2006, severe storms with high winds and possible tornado activity struck St. Louis and the counties of St. Louis, Dent, Iron, Jefferson, Oregon, St. Charles, and Washington. As a result of the storms approximately 500,000 AmerenUE customers were without electrical power. Over 3,600 utility workers from AmerenUE and outlying utility companies were involved in restoration efforts, the largest in company history. High priority projects included restoring power to 14 nursing homes, cooling stations, hospitals, city services, and utility and fuel terminals. Compounding the problems, a heat advisory with heat index values as high as 104°F plagued recovery efforts for several weeks.

In January 2009, a Canadian cold front with a lot of Gulf moisture pushed through Missouri bringing snow, sleet and freezing rain. Over two and one-half inches of ice covered most of the southeast portion of the state. Heavy ice accumulations caused over 3,800 AmerenUE transmission and distribution poles to break. Similar breakages were experienced by municipal and electric cooperative systems and transmission operators Entergy and Southwestern Power Administration, which deliver power to some municipalities in southeastern Missouri. Because of the extent of damage, some people were without power for up to three weeks.

In January 2011 the Missouri Department of Transportation (MODOT) conducted snow-clearing from approximately 1,200 miles of roads in 16 counties that requested help after experiencing record amounts of snow in last week's blizzard in counties that received record amounts of snow. Sixteen of the 44 counties that had record snow requested the assistance from the state. Those counties included Barton, Caldwell, Camden, Dade, Grundy, Johnson, Knox, Lafayette, Lewis, Linn, Livingston, Miller, St. Clair, Schuyler, Sullivan and Vernon. On the afternoon of January 31, a state of emergency was declared for all of Missouri. The order activated the Missouri State Emergency Operations Plan, which allowed state agencies to assist local jurisdictions with emergency preparation and response. The Governor also activated some 600 members of the Missouri National Guard, so they could be positioned around the state to provide help where it was needed most, and directed that emergency generators be deployed around the state.

Sunday, May 22, 2011, a devastating weather event struck Joplin, Missouri, continuing through the cities of Duquesne, Diamond, Granby, Sarcoxie and Wentworth. The National Weather Service identified the event as an EF-5 tornado with winds in excess of 200 miles per hour. The tornado took a direct route through the heart of Joplin's residential and retail district, resulting in hundreds of injuries, deaths and the loss of thousands of homes and businesses. The storm affected electrical power, natural gas, water and communications services. An estimated 3,000 to 4,000 homes were completely destroyed and unserviceable. St John's Mercy Hospital was destroyed.

Measure of Probability and Severity

Probability: High

Severity: Low

Because utilities exist throughout the State and are vulnerable to interruptions or failures, there is a high probability that this hazard may occur at any time or any place throughout the State. In many cases, these are small isolated events, well within the capabilities of the local utility to address. Therefore, the degree of severity of these day-to-day events may be considered low. Due to long-range planning, regulation, and diligence of the utility operators, major interruptions resulting in a high degree of severity are few and far between. Recent regulatory, planning, and structural initiatives designed to minimize interruptions and failures are listed below.

Impact of the Hazard

Utility outages and interruptions can be very localized or region wide. Their greatest impact is generally on the very young or elderly, who can be expected to have greater health risks associated with resultant loss of heating/cooling systems and with the loss of medical equipment that requires a power source. Loss of communications can also adversely affect the provision of emergency services, making it difficult to contact the services for emergency assistance. In addition, utility outages can cause significant problems within the financial community, should there be a long-term loss of their data communications.

Communications

In 1990, the telecommunications staff of the PSC requested that LECs submit plans for disaster recovery. Every LEC in the State submitted a plan that lists practices and procedures for any kind of disaster, natural and manmade. The PSC has recommended to the telecommunication industry that in the event of an emergency, the various companies and emergency agencies should coordinate a single point of contact for emergency situations.

In order to mitigate the damage of earthquakes or other disasters, the LECs added bracing to all their central offices for their switching equipment and batteries. Since earthquakes or other disasters may affect electrical service, which is essential for operations, many companies have obtained on-site generators or made contingency arrangements to acquire them in a disaster. For additional information regarding earthquakes in Missouri, see Section3.3.4 Earthquakes. Such generators would be needed prior to exhaustion of emergency battery supplies, which may last about eight hours.

During the flood of 1993, one LEC provided emergency power to a central office, which was isolated by flood waters. This was accomplished by driving a flatbed truck through the water with a diesel generator mounted on the bed. The generator was fueled by boat.

Vulnerability of buried telecommunications cables has always been a problem. Cables may be subject to accidental or intentional cuts. However, legislation and mitigation procedures have been taken to prevent such events. Senate Bills 214 and 264 provided for the existence of a company called “One Call,” which locates and marks buried utilities. Currently, most LECs in the State have their facilities on record with One Call. Anyone planning any subsurface digging, drilling, or plowing of any kind is advised and encouraged to use One Call. Additional steps to prevent cutting of buried telecommunication cables include clearly marking cable routes with above ground pedestals and poles, as well as patrolling the routes by vehicle and air. In addition to these precautions, most companies are presently building fiber rings for the fiber optic routes to protect continuity of service in the event of an accidental cut.

Since floods pose a threat to telephone service, most companies with buried cables in floodplains are replacing conventional telephone pedestals with flood resistant telephone pedestals, which protect the cables during floods of short duration.

Geomagnetic storms can cripple communications that rely on the ionosphere. Many communication systems use the ionosphere to reflect radio signals over long distances. While TV and commercial radio stations are little affected by solar activity, but ground-to-air, ship-to-shore, shortwave broadcast, and amateur radio (mostly the bands below 30 MHz) are frequently disrupted. Users of these bandwidths include some military detention early warning systems, submarine detection systems, and aircraft. Solar disturbances also damage communications satellites. Increased solar ultraviolet emissions heat the Earth's upper atmosphere causing it to expand. The heated air rises and the density at the orbit of the satellites increases. This creates increased drag on the satellite which in turn causes the satellite to slow and change orbit slightly. Also, during a storm, the number and energy of electrons and ions increases. As a satellite travels through this environment, charge accumulates and can harm the satellite's electrical systems. Damage to communications satellites can disrupt non-terrestrial telephone service, television, radio, and internet service.

Electrical Service

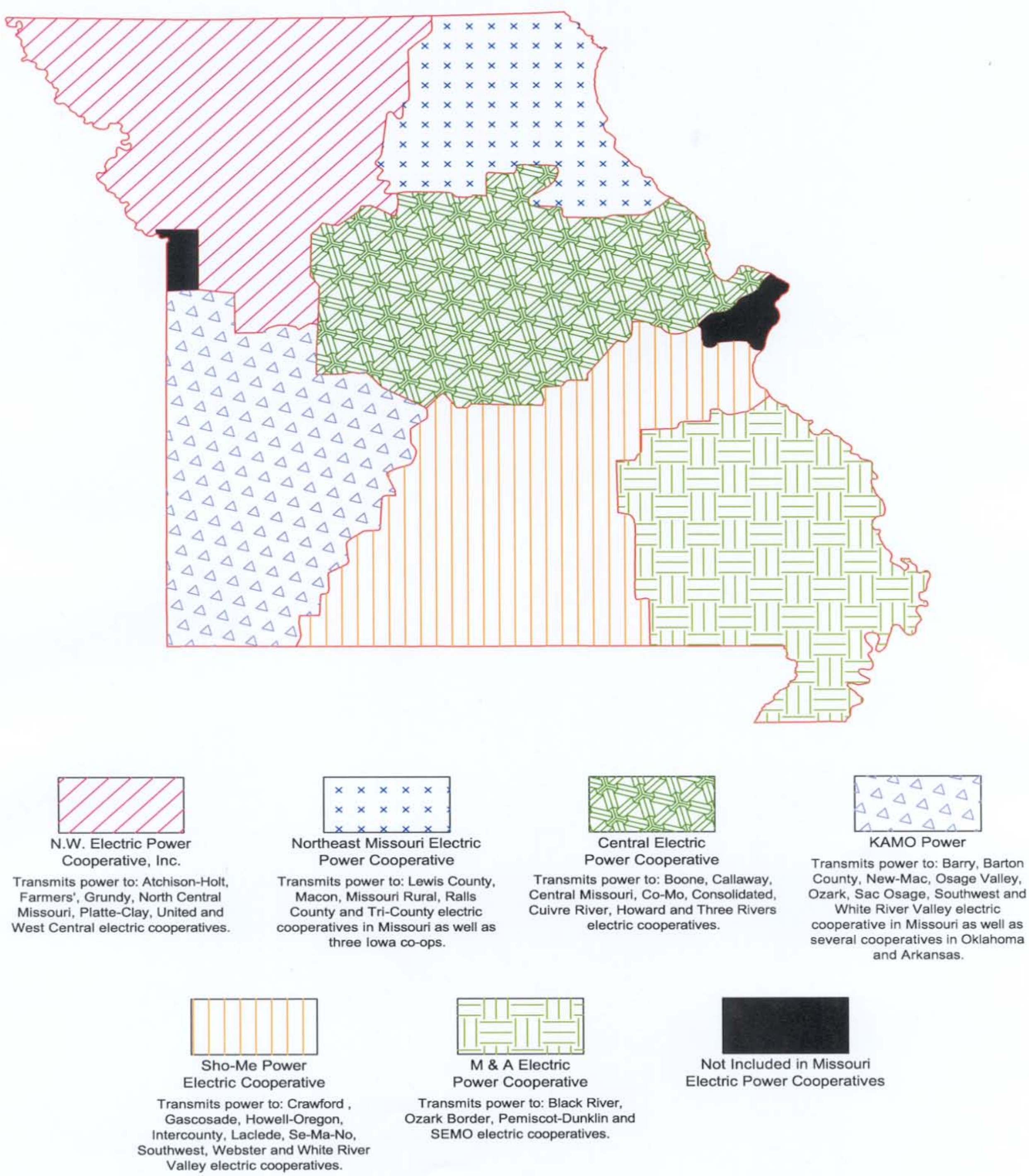
Electrical utilities in Missouri prepare for disasters and power outages by developing written plans to follow when abnormal events cause extensive outages to customers. Power outages caused by severe weather have prompted the creation of tree trimming plans to ensure above ground power lines are free of potential limbs that could fall on power lines and cause interruptions of power if knocked down. In addition, ongoing reviews of emergency plans and training for such events have been implemented. During the 2002 ice storm that struck western and northern Missouri, many customers were unable to contact affected utilities by telephone because there were not enough utility representatives to respond to all customer calls. Therefore, an automated system was developed to allow customers to input information to the computer that automatically generates work orders for service calls. The PSC also advised utility companies to provide feedback to customers that their outage report was recorded.

Missouri's electric cooperatives are non-profit power suppliers owned by their members. Each is governed by a board of directors elected from among the membership. There are 40 distribution cooperatives which provide electricity to individual homes, farms and businesses. Some of these co-ops are quite large while others may serve just one county. Missouri's smallest electric cooperative has just over 2,000 member-owners while our largest has more than 40,000 members. These cooperatives recently produced their first ever hazard mitigation plan. This living planning document was finalized on May 18, 2012 and contains information pertaining to all 47 of the state's electric cooperatives. Appendix A contains the most recent plan available.

Regardless of size, each operates in a similar fashion. Each member-owner has one vote at an annual membership meeting at which bylaws are approved and board members are elected. The board members, each a member of the cooperative, set policy for the co-op to direct day to day operations. Missouri's electric distribution co-ops buy wholesale power from Associated Electric Cooperative, headquartered in Springfield, Mo. Like the local electric cooperatives, Associated operates on a not-for-profit basis and is owned by those who use the services it provides – in this case, Missouri's distribution and transmission cooperatives. Missouri's six transmission cooperatives deliver wholesale electricity from Associated to local distribution co-ops over high-voltage transmission lines. For more information

about specific cooperatives, visit the Association of Missouri Electric Cooperatives at http://www.amec.org/content/missouris-electric-cooperatives. Shown in Figure 3.3.21.1 are the electrical transmission cooperatives.

Figure 3.3.21.1 - Electrical Transmission Cooperatives in Missouri



Source: State Hazard Analysis, October 2009

Natural Gas

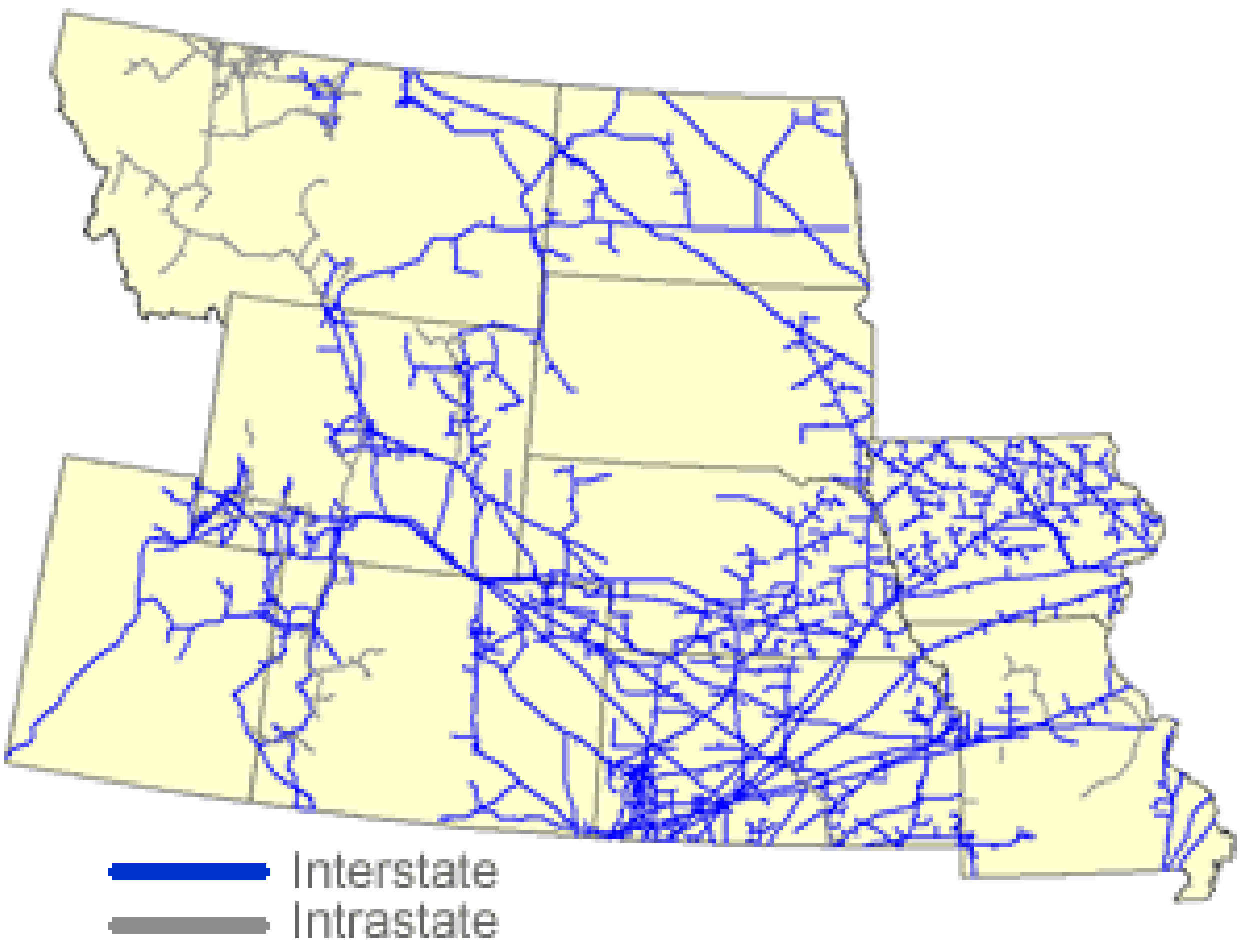
All natural gas system operators in the State operate under the jurisdiction of the Public Service Commission (PSC). These operators must comply with the commission's pipeline safety regulations, which include emergency response procedures to pipeline emergencies and natural disasters. Natural gas system operators have plans on file with the PSC. Part of these plans includes indexes of utilities and their locations in the State.

In 1989, House Bill 938 provided the commission with additional legal power to enforce the Pipeline Safety Regulations. In 1990, due in part to the Iben Browning earthquake projection, all utilities were mandated by the commission to develop natural disaster plans (to include potential impacts of earthquakes) and file the plans with the commission. The commission also developed its own plan to respond to a disaster causing an interruption or failure of a utility service. The Iben Browning earthquake projection created a new awareness for the necessity for such disaster response and recovery plans. Several natural gas companies have since stored emergency equipment and survival rations in protected locations. This also resulted in a new demand for excess flow and motion sensing valves on natural gas service lines. Operators also reviewed, updated or increased their mutual aid agreements with other utilities and contractors.

According to the US Energy Information Administration (EIA), twenty-two interstate and at least thirteen intrastate natural gas pipeline companies operate in the Central Region of the United States (Colorado, Iowa, Kansas, Missouri, Montana, Nebraska, North Dakota, South Dakota, Utah, and Wyoming). Twelve interstate natural gas pipeline systems enter the region from the south and east while four enter from the north carrying Canadian supplies. The average utilization rates on those shipping Canadian natural gas tend to be higher than those carrying domestic supplies.

The region consumes less natural gas than it produces (about 48 percent) and therefore is a net exporter of natural gas. The region has several large metropolitan markets that are major destinations on the regional interstate natural gas pipeline network. Two of the largest are Denver, Colorado, served by Colorado Interstate Gas Company, and Salt Lake City, Utah, which is served by Questar Pipeline Company. Additional markets include the Kansas City metropolitan area of Kansas and Missouri, served by the Southern Star Central Gas Pipeline Company (formerly Williams Gas Pipeline Central), KM Interstate Gas Transmission Company, and Panhandle Eastern Pipeline Company systems; and the St Louis, Missouri, area, which is served by the Centerpoint Mississippi River Transmission Company and Southern Star Central Pipeline Company systems. Figure 3.3.21.2 show interstate Natural Gas Pipelines in the Central Region. According to EIA in 2010, Missouri, there were interstate deliveries of 1,808,599 million cubic feet of natural gas. The Missouri Department of Natural Resources provides a Directory of Missouri Utility and Cooperative Energy Systems which contains the names and contact information for energy providers in Missouri at http://www.dnr.mo.gov/pubs/pub776.pdf

Figure 3.3.21.2 - Major Interstate Natural Gas Pipelines in the Central United States



Source: Energy Information Administration, 2009

In 1990, Senate Bills 214 and 264 required all owners and operators of underground pipeline facilities to participate in the One Call notification center. These bills altered the original Chapter 319 Damage Prevention Act and added a penalty clause. This participation provides for the location of underground pipelines after notification by the excavator and before any excavation work begins.

The information in Table 3.3.21a is from the Impact Analysis of Potential for Detrimental Impacts of Hazards done for the Emergency Management Accreditation Program.

Table 3.3.21a EMAP Impact Analysis: Utilities

Subject	Detrimental Impacts
Health and Safety of Persons in the Area at Time of Incident	Localized impact expected to be moderate to severe for special needs population and moderate to light for others.
Health and Safety of Personnel Responding to the Incident	Nature of hazard expected to minimize any serious damage to properly equipped and trained personnel.
Continuity of Operations	Unlikely to necessitate execution of the Continuity of Operations Plan, although some temporary relocation may be needed.
Property, Facilities, and Infrastructure	Impact on facilities and infrastructure dependent upon the nature of the incident (i.e., electric, water, natural gas, communication disruptions).
Delivery of Services	Disruption of utilities may postpone delivery of some services and require repairs to resume services.
The Environment	Localized adverse impact depending on the nature of the incident.
Economic and Financial Condition	Local economy and finances may be adversely affected, depending on damage.
Regulatory and Contractual Obligations	Regulatory waivers may be needed locally. Fulfillment of some contracts may be difficult. Impact may temporarily reduce deliveries.
Reputation of or Confidence in the Entity	Ability to respond and recover may be questioned and challenged if planning, response, and recovery not timely and effective.

Synopsis

Utility companies are generally well prepared to deal with day-to-day outages. The earthquake threat to statewide and multi-state utilities is the greatest concern to the integrity and operability of Missouri's utilities. Severe weather causes more frequent local, and occasionally widespread, utility outages. Manmade incidents, accidental or intentional, could significantly impact utility service. Geomagnetic storms could disrupt communications and affect utility services. Planning, regulation, mitigation, and mutual aid are all just a few tools available to reduce, speed recovery from, and prevent utility interruptions and failures.

For additional information on vulnerability to utility interruptions and system failures, see Section 3.5.20.

3.4 Overview Analysis of State Development Trends and Assets at Risk

This section begins with an inventory of the buildings and population that could be vulnerable to hazards within the State followed by an analysis of growth trends, including recent changes in population growth and housing unit development at the county level.

This section quantifies the population and buildings exposed to potential hazards, by county. Table 3.4a and Table 3.4b provide numeric breakdowns of this information that form the basis of the vulnerability and risk assessment presented in this plan. This information was derived from inventory data associated with FEMA's loss estimation software Hazus 2.1. Building inventory counts are based on the 2010 census. Inventory values reflect 2010 valuations, based on RSMeans (a supplier of construction cost information) replacement costs. 2010 Population counts are from the U.S. Census Bureau. This table replaces an earlier HAZUS-MH inventory presented in the 2010 version of this plan.

Table 3.4a Population and Building Count

County	Population (2010)	Building Count (HAZUS-MH 2.1)							
		Residential	Commercial	Industrial	Agriculture	Religion	Government	Education	Total
Adair	25,607	11,318	460	88	33	41	32	14	11,986
Andrew	17,291	7,262	254	83	125	33	24	10	7,791
Atchison	5,685	3,018	192	35	44	30	19	6	3,344
Audrain	25,529	10,946	538	142	164	63	43	19	11,915
Barry	35,597	17,395	525	189	49	58	60	21	18,297
Barton	12,402	5,632	287	125	140	35	18	10	6,247
Bates	17,049	7,816	285	57	35	36	29	15	8,273
Benton	19,056	14,004	230	45	14	28	31	11	14,363
Bollinger	12,363	5,856	113	31	13	9	28	10	6,060
Boone	162,642	68,772	2,842	750	293	256	149	64	73,126
Buchanan	89,201	38,404	1,776	483	181	170	79	47	41,140
Butler	42,794	19,709	871	197	116	93	62	22	21,070
Caldwell	9,424	4,624	193	51	93	24	26	14	5,025
Callaway	44,332	18,323	730	216	166	77	53	27	19,592
Camden	44,002	40,088	815	265	46	44	60	19	41,337
Cape Girardeau	75,674	32,340	1,684	418	205	151	70	40	34,908
Carroll	9,295	4,714	201	56	43	24	43	13	5,094
Carter	6,265	3,232	77	19	7	16	22	5	3,378
Cass	99,478	39,350	1,447	598	255	116	61	53	41,880
Cedar	13,982	7,186	280	75	39	31	19	7	7,637
Chariton	7,831	4,260	170	30	31	21	26	9	4,547
Christian	77,422	30,524	1,228	507	156	82	45	30	32,572
Clark	7,139	3,506	142	30	19	15	19	8	3,739
Clay	221,939	91,753	3,484	1,022	241	267	108	85	96,960
Clinton	20,743	8,882	389	127	101	41	29	12	9,581
Cole	75,990	32,085	1,482	363	164	188	1,149	38	35,469
Cooper	17,601	7,460	411	111	142	43	35	20	8,222
Crawford	24,696	11,878	451	200	77	63	28	12	12,709
Dade	7,883	3,967	122	41	22	15	24	11	4,202
Dallas	16,777	7,610	185	53	26	27	23	6	7,930
Daviess	8,433	4,182	209	79	81	18	27	17	4,613
DeKalb	12,892	4,322	189	48	91	18	24	8	4,700
Dent	15,657	7,310	242	45	18	30	23	10	7,678
Douglas	13,684	6,468	118	31	9	15	20	6	6,667
Dunklin	31,953	14,604	798	119	140	93	55	23	15,832
Franklin	101,492	43,141	1,927	779	271	204	89	59	46,470
Gasconade	15,222	8,211	390	129	82	43	28	11	8,894
Gentry	6,738	3,250	177	47	36	22	21	7	3,560
Greene	275,174	123,014	5,174	1,461	353	505	183	115	130,805

County	Population (2010)	Building Count (HAZUS-MH 2.1)							
		Residential	Commercial	Industrial	Agriculture	Religion	Government	Education	Total
Grundy	10,261	5,073	263	56	98	40	27	10	5,567
Harrison	8,957	4,436	243	37	111	40	24	13	4,904
Henry	22,272	10,850	571	169	152	59	43	17	11,861
Hickory	9,627	6,813	84	21	11	12	19	10	6,970
Holt	4,912	2,823	146	38	91	21	18	7	3,144
Howard	10,144	4,599	244	76	116	26	20	11	5,092
Howell	40,400	17,892	928	258	149	96	56	19	19,398
Iron	10,630	5,283	154	49	12	32	29	9	5,568
Jackson	674,158	311,964	13,657	3,715	585	1,278	550	345	332,094
Jasper	117,404	50,378	2,605	702	216	236	96	60	54,293
Jefferson	218,733	86,630	2,821	1,054	254	250	112	79	91,200
Johnson	52,595	21,309	884	283	195	91	56	30	22,848
Knox	4,131	2,306	105	20	14	11	20	2	2,478
Laclede	35,571	15,718	740	227	142	78	40	14	16,959
Lafayette	33,381	14,690	734	209	193	80	57	27	15,990
Lawrence	38,634	16,432	657	213	102	96	46	26	17,572
Lewis	10,211	4,605	192	49	28	30	25	6	4,935
Lincoln	52,566	20,207	755	285	188	77	54	23	21,589
Linn	12,761	6,503	357	74	159	46	39	15	7,193
Livingston	15,195	6,753	370	92	74	38	35	12	7,374
Macon	23,083	7,697	383	100	146	48	44	16	8,434
Madison	15,566	5,978	230	83	26	40	19	6	6,382
Maries	12,226	4,565	139	38	37	15	16	5	4,815
Marion	9,176	12,893	658	162	122	78	39	17	13,969
McDonald	28,781	9,923	231	64	30	26	34	9	10,317
Mercer	3,785	2,150	69	12	7	13	11	4	2,266
Miller	24,748	12,679	532	173	90	55	38	18	13,585
Mississippi	14,358	5,752	259	41	77	37	35	10	6,211
Moniteau	15,607	6,153	285	94	99	32	37	14	6,714
Monroe	8,840	4,805	214	50	58	27	20	13	5,187
Montgomery	12,236	6,119	339	121	125	35	36	9	6,784
Morgan	20,565	15,358	503	172	119	45	33	9	16,239
New Madrid	18,956	8,637	338	57	92	37	54	18	9,233
Newton	58,114	24,072	1,221	376	177	110	60	26	26,042
Nodaway	23,370	9,572	412	128	125	56	48	21	10,362
Oregon	10,881	5,466	150	31	13	21	22	8	5,711
Osage	13,878	6,562	151	60	24	14	26	12	6,849
Ozark	9,723	5,617	96	29	12	8	34	9	5,805
Pemiscot	18,296	8,324	365	64	71	57	40	19	8,940
Perry	18,971	8,483	389	132	95	36	21	11	9,167

County	Population (2010)	Building Count (HAZUS-MH 2.1)							
		Residential	Commercial	Industrial	Agriculture	Religion	Government	Education	Total
Pettis	42,201	18,134	951	268	196	89	47	25	19,710
Phelps	45,156	19,381	984	244	89	106	56	21	20,881
Pike	18,516	7,890	427	107	89	52	32	13	8,610
Platte	89,322	38,356	1,349	404	146	108	71	34	40,468
Polk	31,137	13,108	649	204	156	69	41	20	14,247
Pulaski	52,274	17,709	603	145	60	83	61	22	18,683
Putnam	4,979	2,832	110	21	15	10	19	3	3,010
Ralls	10,167	5,117	198	88	85	18	19	4	5,529
Randolph	25,414	10,801	494	109	35	60	40	19	11,558
Ray	23,494	10,011	378	116	108	48	33	15	10,709
Reynolds	6,696	4,035	69	23	9	10	20	8	4,174
Ripley	14,100	6,618	143	37	13	23	25	10	6,869
Saline	23,370	10,214	441	92	63	68	36	21	10,935
Schuyler	4,431	2,397	71	16	12	10	18	3	2,527
Scotland	4,843	2,344	105	33	14	10	16	3	2,525
Scott	39,191	17,137	884	224	145	103	53	32	18,578
Shannon	8,441	4,142	86	24	11	9	19	8	4,299
Shelby	6,373	3,254	211	63	119	30	25	7	3,709
St. Charles	360,485	137,583	4,788	1,501	388	347	142	116	144,865
St. Clair	9,805	5,629	151	36	23	18	26	8	5,891
St. Francois	65,359	27,887	1,178	334	102	151	59	34	29,745
St. Louis	998,954	176,673	7,714	1,891	143	901	223	180	187,725
St. Louis City*	319,294	437,964	17,201	4,821	844	1,478	556	453	463,317
Ste. Genevieve	18,145	8,619	295	129	64	36	23	9	9,175
Stoddard	29,968	13,673	665	173	176	83	45	20	14,835
Stone	32,202	19,556	474	157	42	58	46	19	20,352
Sullivan	6,714	3,402	140	27	41	17	26	8	3,661
Taney	51,675	27,347	1,321	340	73	123	70	24	29,298
Texas	26,008	11,654	522	147	135	74	46	18	12,596
Vernon	21,159	9,504	403	90	27	37	44	17	10,122
Warren	32,513	14,350	477	175	88	41	29	13	15,173
Washington	25,195	10,938	201	52	11	41	29	13	11,285
Wayne	13,521	8,059	164	52	17	24	28	8	8,352
Webster	36,202	14,183	495	157	85	52	32	23	15,027
Worth	2,171	1,211	49	13	8	5	12	2	1,300
Wright	18,815	8,565	437	88	93	57	27	18	9,285

Sources: U.S. Census Bureau, GCT-T1. Data Set: 2010 Census; HAZUS-MH 2.1.

Table 3.4b Estimated Values for the Key Occupancies (Uses) for the State of Missouri

County	Residential	Commercial	Industrial	Agricultur e	Religion	Governmen t	Education	Total
Adair	1,657,283	263,636	44,101	9,483	32,248	22,582	434,982	2,464,315
Andrew	1,368,815	107,676	16,709	19,827	19,088	15,632	51,633	1,599,380
Atchison	493,264	89,770	9,795	13,879	18,458	11,446	13,807	650,419
Audrain	1,844,508	276,026	107,555	25,385	51,705	31,049	106,436	2,442,664
Barry	2,324,610	288,708	333,215	10,437	47,035	45,799	111,344	3,161,148
Barton	947,715	134,938	119,732	20,398	18,908	12,051	48,006	1,301,748
Bates	1,315,126	138,627	28,906	19,297	21,461	20,791	54,775	1,598,983
Benton	1,998,867	107,878	26,919	8,902	29,525	26,129	42,312	2,240,532
Bollinger	829,178	46,622	12,267	6,140	6,892	18,624	32,822	952,545
Boone	11,760,430	2,375,531	279,637	57,076	184,461	142,578	2,563,526	17,363,239
Buchanan	7,102,375	1,383,384	466,785	28,885	138,189	66,282	515,252	9,701,152
Butler	2,604,836	637,624	111,551	25,814	46,555	44,007	211,786	3,682,173
Caldwell	782,537	61,232	9,321	13,396	12,487	18,788	44,374	942,135
Callaway	3,109,651	559,029	88,580	21,138	47,046	37,899	270,957	4,134,300
Camden	6,225,128	509,014	112,536	6,602	38,086	48,401	196,572	7,136,339
Cape Girardeau	5,617,890	1,243,285	236,888	35,659	121,460	49,293	652,958	7,957,433
Carroll	803,041	104,980	46,644	20,322	16,294	38,032	36,948	1,066,261
Carter	437,495	31,313	14,786	1,172	8,515	16,895	19,912	530,088
Cass	8,823,141	642,131	187,474	47,755	79,828	51,883	413,212	10,245,424
Cedar	1,039,634	204,108	47,694	8,924	20,791	15,299	41,127	1,377,577
Chariton	669,250	71,278	13,428	18,746	12,642	17,479	18,972	821,795

County	Residential	Commercial	Industrial	Agricultur e	Religion	Governmen t	Education	Total
Christian	5,354,863	442,357	180,355	20,326	69,684	34,789	251,967	6,354,341
Clark	494,174	53,723	12,850	8,659	8,544	12,735	24,310	614,995
Clay	19,998,806	3,019,803	753,940	35,028	263,448	101,982	1,067,356	25,240,363
Clinton	1,792,473	158,788	39,102	12,731	29,603	20,220	90,841	2,143,758
Cole	6,027,960	1,072,172	157,739	22,458	192,430	1,231,336	401,853	9,105,948
Cooper	1,302,502	199,324	51,346	22,319	28,591	23,380	70,889	1,698,351
Crawford	1,752,866	193,683	94,329	9,772	35,459	18,896	61,535	2,166,540
Dade	570,949	48,884	27,611	9,395	13,656	14,704	27,680	712,879
Dallas	1,116,692	80,143	24,391	7,575	16,195	16,279	36,058	1,297,333
Daviess	698,656	55,368	42,017	9,835	8,898	16,091	34,731	865,596
DeKalb	749,561	78,320	9,381	11,974	9,440	14,859	18,221	891,756
Dent	1,124,511	133,982	34,287	5,292	20,724	17,978	45,798	1,382,572
Douglas	878,233	62,989	17,478	4,909	16,315	17,503	31,581	1,029,008
Dunklin	1,859,137	373,817	32,690	31,248	52,948	31,268	111,669	2,492,777
Franklin	7,946,690	987,762	614,408	40,044	139,423	66,481	481,339	10,276,147
Gasconad e	1,358,591	159,166	67,060	12,698	26,353	22,444	53,625	1,699,937
Gentry	490,102	90,544	11,848	12,253	10,876	13,311	17,671	646,605
Greene	20,373,788	3,981,123	842,437	61,916	438,709	166,917	2,084,810	27,949,700
Grundy	761,500	129,478	22,553	12,223	20,828	14,917	61,569	1,023,068
Harrison	761,519	124,439	6,238	14,102	19,094	12,512	37,693	975,597
Henry	1,762,930	307,184	121,310	26,896	32,981	32,190	99,959	2,383,450
Hickory	800,847	37,309	7,788	2,630	8,073	15,018	27,113	898,778

County	Residential	Commercial	Industrial	Agriculture	Religion	Government	Education	Total
Holt	467,507	49,789	13,404	16,449	16,372	11,310	17,023	591,854
Howard	763,222	77,247	19,824	18,996	22,544	13,475	94,836	1,010,144
Howell	2,579,749	428,699	116,616	17,047	51,584	37,795	176,641	3,408,131
Iron	755,769	77,458	33,528	2,578	24,642	18,589	48,417	960,981
Jackson	62,142,804	12,211,323	2,947,894	109,247	1,236,277	593,361	4,144,610	83,385,516
Jasper	8,040,516	1,456,370	438,005	45,571	172,749	70,478	646,911	10,870,600
Jefferson	17,223,681	1,408,309	542,560	36,749	220,711	101,839	995,509	20,529,358
Johnson	3,772,658	419,147	134,338	25,707	66,744	47,594	586,738	5,052,926
Knox	321,800	34,644	4,207	10,971	5,204	13,495	8,648	398,969
Laclede	2,193,722	354,534	123,191	18,154	46,950	30,342	131,696	2,898,589
Lafayette	2,784,793	346,019	78,791	35,264	55,137	42,091	177,451	3,519,546
Lawrence	2,601,495	335,067	137,913	27,993	59,819	33,335	128,748	3,324,370
Lewis	690,594	68,652	27,059	13,521	17,750	17,125	64,355	899,056
Lincoln	3,608,615	313,815	98,208	29,524	50,078	44,201	195,590	4,340,031
Linn	999,604	150,161	34,752	22,090	23,932	25,243	57,426	1,313,208
Livingston	1,017,803	196,932	67,481	12,183	21,701	18,682	50,712	1,385,494
Macon	1,139,026	155,079	28,075	19,218	26,365	29,220	63,283	1,460,266
Madison	808,411	160,701	43,330	4,111	24,850	14,119	35,556	1,091,078
Maries	728,228	40,426	36,513	9,317	9,565	10,112	17,477	851,638
Marion	2,129,294	326,165	87,356	18,234	48,949	25,924	153,913	2,789,835
McDonald	1,281,441	67,581	38,892	8,030	17,082	20,786	64,259	1,498,071
Mercer	313,774	24,813	2,833	4,015	5,744	6,557	9,816	367,552

County	Residential	Commercial	Industrial	Agriculture	Religion	Government	Education	Total
Miller	1,768,934	194,385	60,592	13,017	28,492	28,307	100,858	2,194,585
Mississippi	862,331	86,801	13,316	19,082	22,046	21,393	41,645	1,066,614
Moniteau	1,049,444	94,973	61,280	14,371	20,390	30,914	44,561	1,315,933
Monroe	719,050	66,573	32,581	11,405	17,066	12,458	41,449	900,582
Montgomery	945,296	134,444	70,508	18,469	18,109	27,143	40,619	1,254,588
Morgan	2,153,268	198,535	51,404	17,497	29,430	27,494	41,155	2,518,783
New Madrid	1,228,327	139,017	59,261	15,843	20,388	34,713	72,380	1,569,929
Newton	3,708,537	752,656	163,775	21,072	77,425	39,616	264,776	5,027,857
Nodaway	1,448,529	177,822	67,035	22,505	29,398	24,908	327,198	2,097,395
Oregon	704,724	63,299	8,918	5,503	14,975	15,271	29,996	842,686
Osage	1,166,860	71,423	70,031	12,519	8,980	19,319	78,703	1,427,835
Ozark	674,042	41,486	17,427	3,488	5,883	20,822	21,718	784,866
Pemiscot	1,058,979	189,530	46,806	11,258	28,064	22,734	76,283	1,433,654
Perry	1,582,591	213,183	151,689	27,850	45,724	17,340	85,872	2,124,249
Pettis	3,115,585	603,582	202,010	36,209	52,855	35,819	265,143	4,311,203
Phelps	3,123,407	537,523	93,945	11,042	68,287	44,734	404,102	4,283,040
Pike	1,334,652	213,706	51,486	16,974	28,316	24,578	63,243	1,732,955
Platte	8,459,563	886,789	248,083	23,839	95,143	66,643	400,505	10,180,565
Polk	1,926,478	238,253	46,592	23,574	35,258	32,598	204,085	2,506,838
Pulaski	3,142,161	290,583	47,011	7,474	56,053	51,643	160,401	3,755,326
Putnam	386,183	58,683	8,098	8,938	5,140	14,209	11,962	493,213
Ralls	842,549	63,322	79,522	12,402	10,706	15,592	11,956	1,036,049

County	Residential	Commercial	Industrial	Agriculture	Religion	Government	Education	Total
Randolph	1,655,588	281,380	90,835	11,080	36,515	30,404	232,152	2,337,954
Ray	2,003,702	161,975	44,563	25,359	28,241	24,475	69,001	2,357,316
Reynolds	552,408	106,201	18,670	1,575	8,714	12,527	17,447	717,542
Ripley	821,433	88,919	44,819	3,338	14,985	18,511	58,111	1,050,116
Saline	1,762,573	243,181	69,516	19,809	43,436	23,488	164,435	2,326,438
Schuyler	306,421	27,948	2,850	5,556	5,406	10,725	10,188	369,094
Scotland	355,839	68,007	11,573	9,682	4,542	9,113	16,470	475,226
Scott	2,681,651	512,881	144,289	25,481	71,191	41,052	159,973	3,636,518
Shannon	631,602	28,359	12,548	3,107	6,253	15,407	28,281	725,557
Shelby	490,953	61,495	43,339	18,735	21,932	12,500	28,668	677,622
St. Charles	32,280,959	3,315,000	808,965	62,566	324,991	135,724	2,228,945	39,157,150
St. Clair	768,026	107,823	9,037	8,813	12,564	19,561	23,470	949,294
St. Francois	4,584,520	778,903	184,858	14,003	113,908	51,489	345,608	6,073,289
St. Louis	27,757,391	8,246,761	2,364,136	21,631	877,625	228,654	1,918,059	41,414,257
St. Louis City*	97,273,559	16,787,295	4,844,894	208,337	1,398,844	553,031	6,431,778	127,497,738
Ste. Genevieve	1,579,829	163,283	108,486	9,028	20,733	17,124	68,922	1,967,405
Stoddard	2,037,250	267,367	86,789	29,702	45,166	31,149	91,871	2,589,294
Stone	2,971,002	177,539	40,012	7,064	49,664	38,168	92,593	3,376,042
Sullivan	428,708	59,143	29,265	6,979	9,713	14,956	17,379	566,143
Taney	3,683,469	687,404	68,152	8,939	79,470	45,743	135,770	4,708,947
Texas	1,616,447	195,667	59,926	18,539	55,817	30,751	82,729	2,059,876
Vernon	1,538,034	594,410	56,554	12,981	21,862	27,122	101,216	2,352,179

County	Residential	Commercial	Industrial	Agriculture	Religion	Government	Education	Total
Warren	2,611,219	208,321	123,392	11,712	30,676	24,144	96,201	3,105,665
Washington	1,420,716	113,063	18,327	2,274	32,936	22,624	68,901	1,678,841
Wayne	1,000,342	67,311	38,345	2,956	20,386	17,767	34,443	1,181,550
Webster	2,204,821	178,728	61,670	15,179	28,631	23,760	116,102	2,628,891
Worth	211,892	13,359	3,641	4,442	1,946	6,489	6,258	248,027
Wright	1,169,950	138,019	32,394	16,600	34,993	20,028	77,053	1,489,037
Total	493,898,424	78,766,389	21,613,666	2,258,287	8,777,963	6,027,156	34,400,230	645,742,115

Source: HAZUS-MH 2.1

Note: *All $ values are in thousands

Assessing Vulnerability: Growth and Development

As part of the plan update process, the State looked at changes in growth and development and examined these changes in the context of the State's hazard-prone areas and how the changes in growth and development affect loss estimates and vulnerability. When the population in a hazardous area increases, so does the vulnerability of people and property associated with the hazards unless mitigation measures are taken. When a population in a hazard area decreases, the burden for assuming the loss to vulnerable property may exceed the resources of the declining population

As part of the update process, the State reviewed baseline information from the original local hazard mitigation plans, paying particular attention to the high-growth counties. Since these plans were first generation plans, trend information beyond baseline data (e.g., population, land area) was generally not discussed. Notable and important development trends illustrated in future local hazard mitigation plan updates (e.g., changes in land use in hazardous areas, mitigation successes), where discussed, will be captured in future state plan updates. The discussion here focuses on population growth and increases in housing units and density by county, based on U.S. Census Bureau data. Detailed spreadsheets containing this data are available at by clicking this census data link.

Population

In the 2010 Census released by the U.S. Census Bureau (December 2010), Missouri ranked 18th among the 50 states in population, 18th in land area (68,741 square miles), 27th in rate of growth, and 28th in population density. In 1830, the first year of statehood, Missouri had a population of 140,455. Decennial census findings from the last few decades and the most recent estimate illustrate Missouri's growth (see Table 3.4c).

Table 3.4c Missouri's Population Growth

Census	Total Population	Ten-year % Change	Average Annual % Change
1970	4,677,623	--	--
1980	4,917,444	5.13%	0.051%
1990	5,117,073	4.06%	0.041%
2000	5,595,211	9.34%	0.093%
2010	5,988,927	7.04%	0.070%

Source: US. Census Bureau

The most recent U.S. Census Bureau Census places Missouri's 2010 population at 5,988,927, a growth of 7.0% since 2000. The annual average growth rate was 0.051% in the 1970s, 0.041% in the 1980s, 0.093% in the 1990s, and slightly down to 0.070% from 2000 to 2010. Other population characteristics are presented in Table 3.4d. All County level data are from 2010 Census Bureau census.

Table 3.4d Missouri Quick Facts

Population 2010 Census	5,988,927
Population, percent change, April 1, 2010 to July 1, 2011	0.4%

Land Area in Square Miles (2010)	68,741
Persons per Square Mile (2010)	87.1
Number of Incorporated Cities, Towns, and Villages	951
Housing Units (2011)	2,723,415
Housing Units per Square Mile (2011)	39.5
Number of Counties (with St. Louis City*)	115
Counties with a 2010 population estimate; Greater than 500,000	2 (St, Louis, Jackson)
200,000 to 499,000	5 (St Louis City, St. Charles, Greene, Jefferson, Clay)
100,000 to 199,99	3 (Boone, Jasper, Franklin)
50,000 to 99,999	12
25,000 to 49,999	23
15,000 to 24,999	26
10,000 to 14,999	18
1 to 9,999	26

Source: US. Census Bureau

Figure 3.4.1 on the following page illustrates Missouri's population by county based upon the 2010 census.

Figure 3.4.1 - Counties by Population, 2010

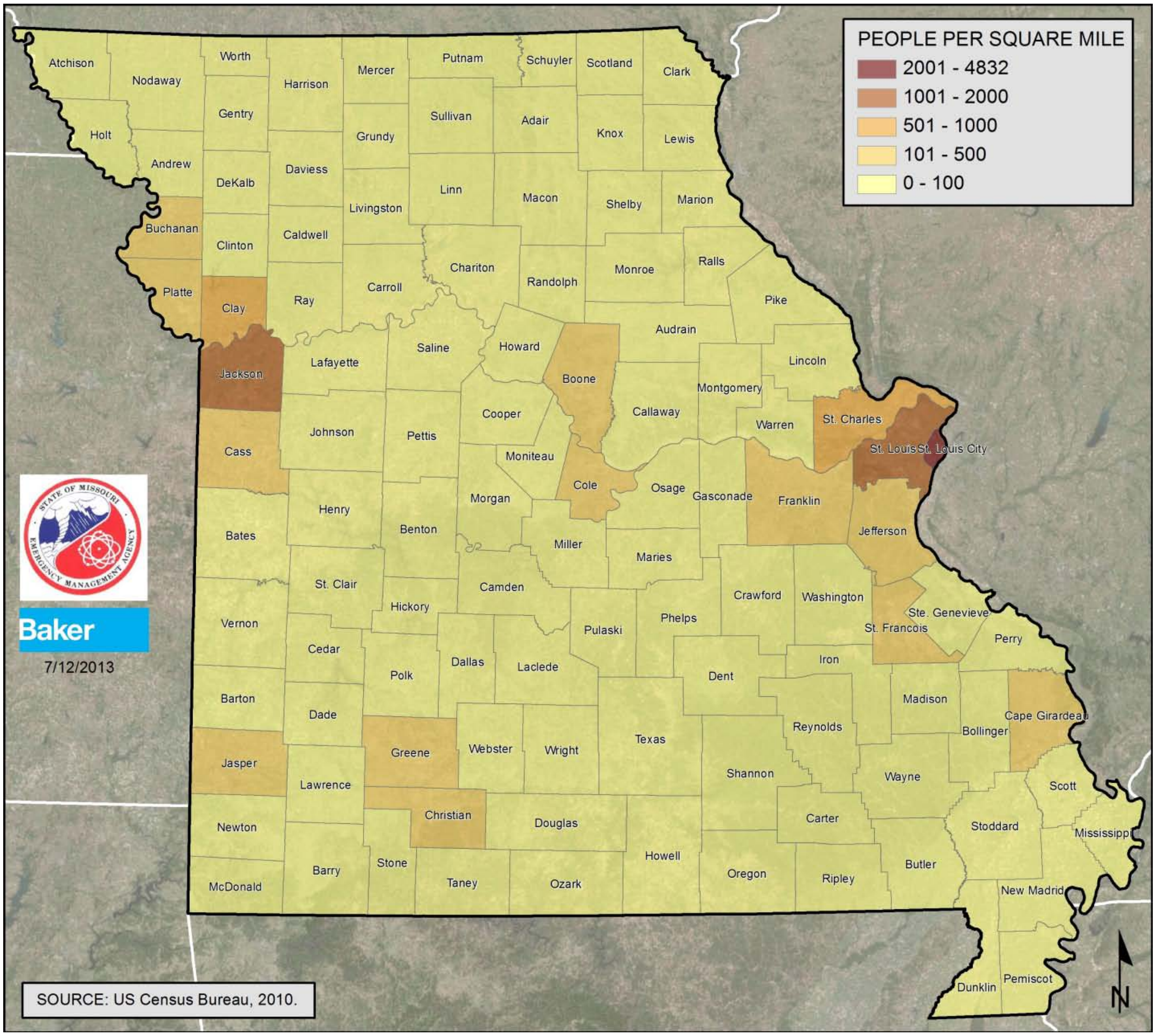


Figure 3.4.1, above, provides the population for all counties based upon the Census Bureau's 2010 Census.

Table 3.4e Missouri County Population Changes 2000 to 2010

COUNTY	2010	2000	% Change 2000 to 2010	Population Change
Missouri Statewide	5,988,927	5,595,211	7.0%	393,716
Adair County	25,607	24,977	2.5	630
Andrew County	17,291	16,492	4.8	799
Atchison County	5,685	6,430	-11.6	-745
Audrain County	25,529	25,853	-1.3	-324
Barry County	35,597	34,010	4.7	1,587
Barton County	12,402	12,541	-1.1	-139
Bates County	17,049	16,653	2.4	396
Benton County	19,056	17,180	10.9	1,876
Bollinger County	12,363	12,029	2.8	334
Boone County	162,642	135,454	20.1	27,188
Buchanan County	89,201	85,998	3.7	3,203
Butler County	42,794	40,867	4.7	1,927
Caldwell County	9,424	8,969	5.1	455
Callaway County	44,332	40,766	8.7	3,566
Camden County	44,002	37,051	18.8	6,951
Cape Girardeau County	75,674	68,693	10.2	6,981
Carroll County	9,295	10,285	-9.6	-990
Carter County	6,265	5,941	5.5	324
Cass County	99,478	82,092	21.2	17,386
Cedar County	13,982	13,733	1.8	249
Chariton County	7,831	8,438	-7.2	-607
Christian County	77,422	54,285	42.6	23,137
Clark County	7,139	7,416	-3.7	-277
Clay County	221,939	184,006	20.6	37,933
Clinton County	20,743	18,979	9.3	1,764
Cole County	75,990	71,397	6.4	4,593
Cooper County	17,601	16,670	5.6	931
Crawford County	24,696	22,804	8.3	1,892
Dade County	7,883	7,923	-0.5	-40
Dallas County	16,777	15,661	7.1	1,116
Daviess County	8,433	8,016	5.2	417
DeKalb County	12,892	11,597	11.2	1,295
Dent County	15,657	14,927	4.9	730

COUNTY	2010	2000	% Change 2000 to 2010	Population Change
Douglas County	13,684	13,084	4.6	600
Dunklin County	31,953	33,155	-3.6	-1,202
Franklin County	101,492	93,807	8.2	7,685
Gasconade County	15,222	15,342	-0.8	-120
Gentry County	6,738	6,861	-1.8	-123
Greene County	275,174	240,391	14.5	34,783
Grundy County	10,261	10,432	-1.6	-171
Harrison County	8,957	8,850	1.2	107
Henry County	22,272	21,997	1.3	275
Hickory County	9,627	8,940	7.7	687
Holt County	4,912	5,351	-8.2	-439
Howard County	10,144	10,212	-0.7	-68
Howell County	40,400	37,238	8.5	3,162
Iron County	10,630	10,697	-0.6	-67
Jackson County	674,158	654,880	2.9	19,278
Jasper County	117,404	104,686	12.1	12,718
Jefferson County	218,733	198,099	10.4	20,634
Johnson County	52,595	48,258	9.0	4,337
Knox County	4,131	4,361	-5.3	-230
Laclede County	35,571	32,513	9.4	3,058
Lafayette County	33,381	32,960	1.3	421
Lawrence County	38,634	35,204	9.7	3,430
Lewis County	10,211	10,494	-2.7	-283
Lincoln County	52,566	38,944	35.0	13,622
Linn County	12,761	13,754	-7.2	-993
Livingston County	15,195	14,558	4.4	637
Macon County	15,566	15,762	-1.2	-196
Madison County	12,226	11,800	3.6	426
Maries County	9,176	8,903	3.1	273
Marion County	28,781	28,289	1.7	492
McDonald County	23,083	21,681	6.5	1,402
Mercer County	3,785	3,757	0.7	28
Miller County	24,748	23,564	5.0	1,184
Mississippi County	14,358	13,427	6.9	931
Moniteau County	15,607	14,827	5.3	780
Monroe County	8,840	9,311	-5.1	-471

COUNTY	2010	2000	% Change 2000 to 2010	Population Change
Montgomery County	12,236	12,136	0.8	100
Morgan County	20,565	19,309	6.5	1,256
New Madrid County	18,956	19,760	-4.1	-804
Newton County	58,114	52,636	10.4	5,478
Nodaway County	23,370	21,912	6.7	1,458
Oregon County	10,881	10,344	5.2	537
Osage County	13,878	13,062	6.2	816
Ozark County	9,723	9,542	1.9	181
Pemiscot County	18,296	20,047	-8.7	-1,751
Perry County	18,971	18,132	4.6	839
Pettis County	42,201	39,403	7.1	2,798
Phelps County	45,156	39,825	13.4	5,331
Pike County	18,516	18,351	0.9	165
Platte County	89,322	73,781	21.1	15,541
Polk County	31,137	26,992	15.4	4,145
Pulaski County	52,274	41,165	27.0	11,109
Putnam County	4,979	5,223	-4.7	-244
Ralls County	10,167	9,626	5.6	541
Randolph County	25,414	24,663	3.0	751
Ray County	23,494	23,354	0.6	140
Reynolds County	6,696	6,689	0.1	7
Ripley County	14,100	13,509	4.4	591
Saline County	23,370	23,756	-1.6	-386
Schuyler County	4,431	4,170	6.3	261
Scotland County	4,843	4,983	-2.8	-140
Scott County	39,191	40,422	-3.0	-1,231
Shannon County	8,441	8,324	1.4	117
Shelby County	6,373	6,799	-6.3	-426
St. Charles County	360,485	283,883	27.0	76,602
St. Clair County	9,805	9,652	1.6	153
St. Francois County	65,359	55,641	17.5	9,718
St. Louis City*	319,294	348,189	-8.3	-28,895
St. Louis County	998,954	1,016,315	-1.7	-17,361
Ste. Genevieve County	18,145	17,842	1.7	303
Stoddard County	29,968	29,705	0.9	263
Stone County	32,202	28,658	12.4	3,544

COUNTY	2010	2000	% Change 2000 to 2010	Population Change
Sullivan County	6,714	7,219	-7.0	-505
Taney County	51,675	39,703	30.2	11,972
Texas County	26,008	23,003	13.1	3,005
Vernon County	21,159	20,454	3.4	705
Warren County	32,513	24,525	32.6	7,988
Washington County	25,195	23,344	7.9	1,851
Wayne County	13,521	13,259	2.0	262
Webster County	36,202	31,045	16.6	5,157
Worth County	2,171	2,382	-8.9	-211
Wright County	18,815	17,955	4.8	860

Source: U.S. Census Bureau, Data Set: 2010 U.S. Census

Figure 3.4.2 and Figure 3.4.3 illustrate county population changes by count and by percent statewide.

Figure 3.4.2 - Change in Population by County, 2000-2010

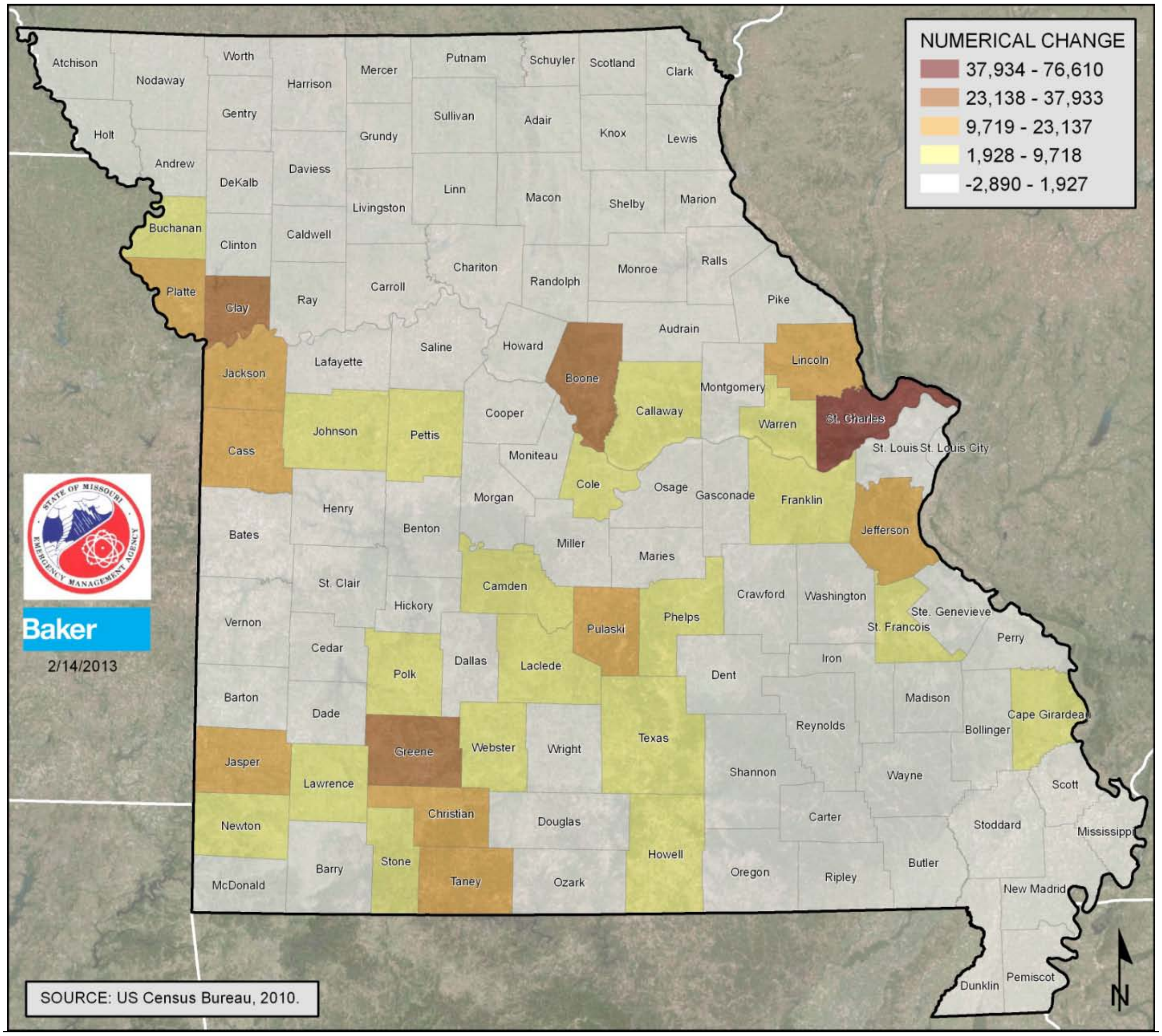
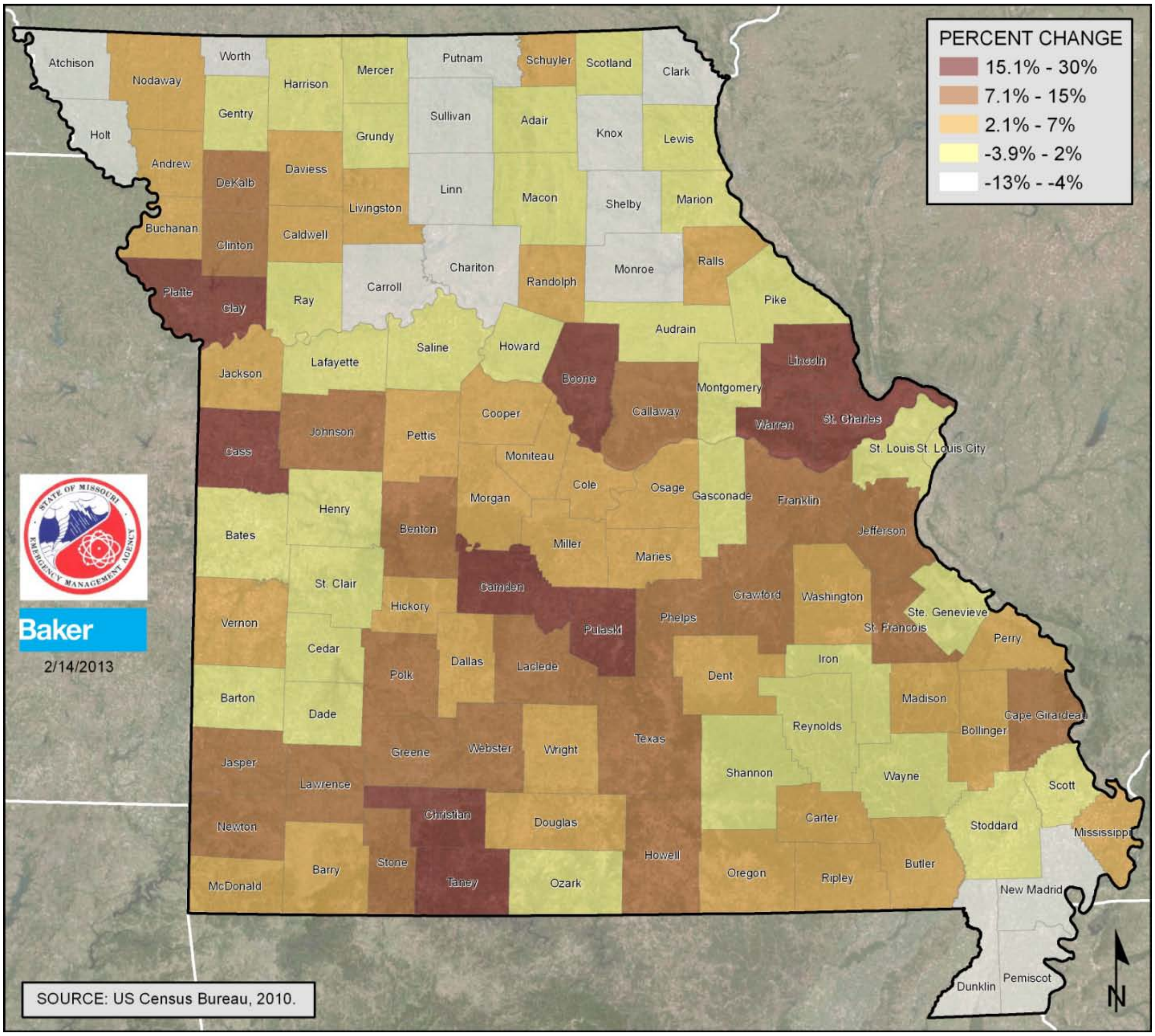


Figure 3.4.3 - Percent Change in Population by County, 2000-2010



Between 2000 and 2010, 85 counties gained population, 47 of which (40 percent of all counties) each gained more than 5 percent. 67 percent of the increase is attributed to natural increase (number of births exceeding the number of deaths), and 33 percent is attributed to migration into the State (OSEDA 2012).

Figure 3.4.4 - Natural Increase of Missouri Population by County, 2000-2009

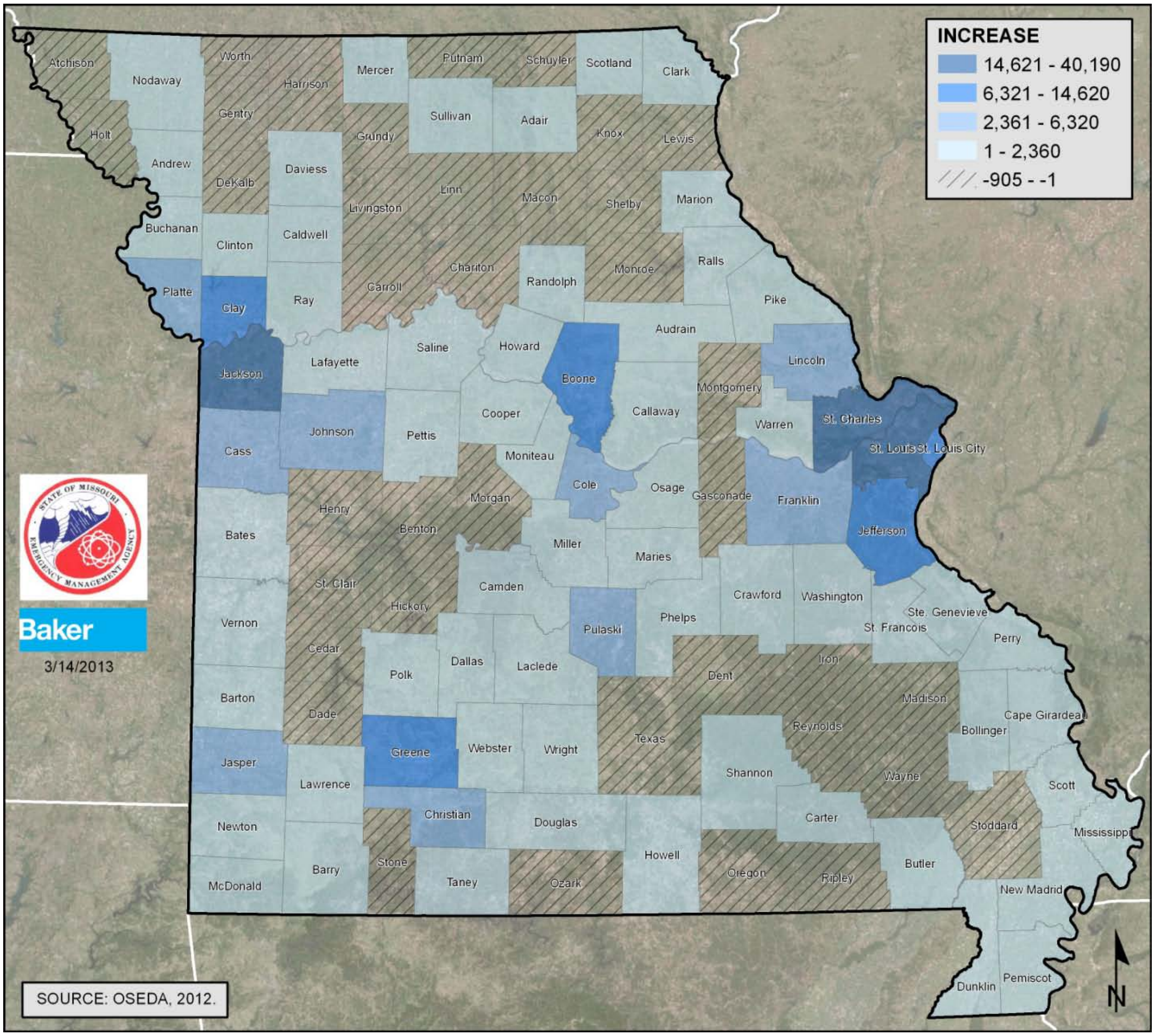


Table 3.4f Missouri Counties with Population Increases 5% or Greater 2000 to 2010

COUNTY	Percent Increase 2000 to 2010
Statewide	**7.0%**
Christian County	42.6%
Lincoln County	35.0%
Warren County	32.6%
Taney County	30.2%
Pulaski County	27.0%
St. Charles County	27.0%
Cass County	21.2%
Platte County	21.1%
Clay County	20.6%
Boone County	20.1%
Camden County	18.8%
St. Francois County	17.5%
Webster County	16.6%
Polk County	15.4%
Greene County	14.5%
Phelps County	13.4%
Texas County	13.1%
Stone County	12.4%
Jasper County	12.1%
Dekalb County	11.2%
Benton County	10.9%
Jefferson County	10.4%
Newton County	10.4%
Cape Girardeau County	10.2%
Lawrence County	9.7%
Laclede County	9.4%
Clinton County	9.3%
Johnson County	9.0%
Callaway County	8.7%
Howell County	8.5%
Crawford County	8.3%
Franklin County	8.2%
Washington County	7.9%

COUNTY	Percent Increase 2000 to 2010
Hickory County	7.7%
Dallas County	7.1%
Pettis County	7.1%
Mississippi County	6.9%
Nodaway County	6.7%
Morgan County	6.5%
McDonald County	6.5%
Cole County	6.4%
Schuyler County	6.3%
Osage County	6.2%
Ralls County	5.6%
Cooper County	5.6%
Carter County	5.5%
Moniteau County	5.3%
Daviess County	5.2%
Oregon County	5.2%
Caldwell County	5.1%
Miller County	5.0%

Source: US. Census Bureau

St. Louis County ranked 40th and Jackson County, ranked 89th, among the nation's 100 most populous counties in 2013. Table 3.4g lists Missouri's 10 most populous counties.

Table 3.4g Top 10 Most Populated Missouri Counties, 2000-2010

COUNTY	2010 Population	2000 Population	Percent change 2000 to 2010
St. Louis County	998,954	1,016,315	-1.7%
Jackson County	674,158	654,880	2.9%
St. Charles County	360,485	283,883	27.0%
St. Louis City*	319,294	348,189	-8.3%
Greene County	275,174	240,391	14.5%
Clay County	221,939	184,006	20.6%
Jefferson County	218,733	198,099	10.4%
Boone County	162,642	135,454	20.1%
Jasper County	117,404	104,686	12.1%
Franklin County	101,492	93,807	8.2%

Source: U. S. Census Bureau, Population Division; Note: *St. Louis City* is considered both a "place" and a "county" by the U.S. Census Bureau, so it is treated here as a county as well as a city

Growth in Missouri counties over the past few decades has also been attributed to a robust national and regional economy that led to low unemployment and reasonable interest rates. Although these growth factors have been dampened by the recent economic slowdown, not every county has been affected to the same extent. A report from the Brookings Institution suggests that Missouri is decentralizing to low population density areas and that this development pattern will exacerbate the fiscal problems of state and local governments by increasing the cost of providing infrastructure and services in rural areas. (Brookings 2002). The report also emphasizes the need for the State to monitor the effect that additional land consumption will have regarding newly developed areas and buildings. The demand for infrastructure resources in the developing areas will be accompanied by new hazard mitigation needs. Table 3.4h lists the ten counties with the greatest population growth.

Table 3.4h Counties with Greatest Estimated Population Gains (Numerical), 2000-2010

County	Population Increase 2000-2010	Percent Increase 2000-2010	2010 Population (Est.)
St. Charles County	76,602	27.0%	360,485
Clay County	37,933	20.6%	221,939
Greene County	34,783	14.5%	275,174
Boone County	27,188	20.1%	162,642
Christian County	23,137	42.6%	77,422
Jefferson County	20,634	10.4%	218,733
Jackson County	19,278	2.9%	674,158
Cass County	17,386	21.2%	99,478
Platte County	15,541	21.1%	89,322
Lincoln County	13,622	35.0%	52,566

Source: U. S. Census Bureau

Christian County ranked 44th among the nation's 100 fastest growing counties with populations greater than 5,000 (Census 2010). Located between Springfield and the Branson/Tri-Lakes area, Christian County attributes its growth to the growth of the tourism and recreation economies and transportation system improvements (Southwest Missouri 2005). Lincoln and St. Charles counties, part of the St. Louis metropolitan area, attribute their growth to their proximity to the St. Louis metropolitan area. They also credit improved transportation routes, telecommunications, low-cost housing and transportation. The nationwide trend toward decentralization and suburbanization is exacerbated by the stigma of poverty and crime associated with urban areas and the flight of wealth from the central metropolitan core (Gordon 2008).

Table 3.4i lists the ten counties that have the highest growth rates (percent change from 2000 to 2010. These top growing counties are responsible for 63 percent of Missouri's population increase during the period.

Table 3.4i Counties with Greatest Estimated Population Gains (Percent), 2000-2010

County	2010	2000	Population Change	Percent change 2000 to 2010
Christian County	77,422	54,285	23,137	42.6%
Lincoln County	52,566	38,944	13,622	35.0%
Warren County	32,513	24,525	7,988	32.6%
Taney County	51,675	39,703	11,972	30.2%
Pulaski County	52,274	41,165	11,109	27.0%
St. Charles County	360,485	283,883	76,602	27.0%
Cass County	99,478	82,092	17,386	21.2%
Platte County	89,322	73,781	15,541	21.1%
Clay County	221,939	184,006	37,933	20.6%
Boone County	162,642	135,454	27,188	20.1%
Subtotal of Ten Counties	1,200,316	957,838	242,478	20.1%
Missouri	5,988,927	5,595,211	316,394	5.7%

Source: US. Census Bureau

Not all of Missouri's counties are growing, however (refer to Table 3.4j and Table 3.4k). Two of the most populous counties (St. Louis County and St. Louis City*) also lost the greatest number of people. Of the counties with the greatest or most rapid losses, one of them (Atchison) also rank among Missouri's 10 least populous counties (see Table 3.4l). Six of them (Linn, Chariton, Atchison, Carroll, Pemiscot, St. Louis City) rank in the top 10 by number of people lost as well as percent lost.

Table 3.4j Counties with Greatest Estimated Population Losses (Numerical), 2000-2010

County	Population Decrease (##)	Percent Decease
St. Louis City	-28,895	-8.3%
St. Louis County	-17,361	-1.7%
Pemiscot County	-1,751	-8.7%
Scott County	-1,231	-3.0%
Dunklin County	-1,202	-3.6%
Linn County	-993	-7.2%
Carroll County	-990	-9.6%
New Madrid County	-804	-4.1%
Atchison County	-745	-11.6%
Chariton County	-607	-7.2%

Source: US. Census Bureau

Table 3.4k Counties with Greatest Estimated Population Losses (Percent), 2000-2010

County	Population Decrease (##)	Percent Decrease
Atchison County	-745	--11.6%
Carroll County	-990	-9.6%
Worth County	-211	-8.9%
Pemiscot County	-1,751	-8.7%
St. Louis City	-28,895	-8.3%
Holt County	-439	-8.2%
Chariton County	-607	-7.2%
Linn County	-993	-7.2%
Sullivan County	-505	-7.0%
Shelby County	-426	-6.3%

Source: US. Census Bureau

Table 3.4l Ten Least Populated Missouri Counties, 2010 Census Estimate

County	2010 Population	Percent Change	Population Change 2000-2010
Worth County	2,171	-8.9%	-211
Mercer County	3,785	0.7%	28
Knox County	4,131	-5.3%	-230
Schuyler County	4,431	6.3%	261
Scotland County	4,843	-2.8%	-140
Holt County	4,912	-8.2%	-439
Putnam County	4,979	-4.7%	-244
Atchison County	5,685	-11.6%	-745
Carter County	6,265	5.5%	324
Shelby County	6,373	-6.3%	-426
Reynolds County	6,696	-8.9%	-211

Source: US. Census Bureau

Interim population projections issued by the U.S. Census Bureau in 2010 suggest that Missouri's population will continue to grow, but percentages will drop, over the next three decades (see Table 3.4m).

Table 3.4m Interim Missouri Population Projections, 2010-2030

Year	Population	Percent Change
2000	5,596,687	--

Year	Population	Percent Change
2005	5,785,130	3.3%
2010	5,979,344	3.4%
2015	6,184,390	3.4%
2020	6,389,850	3.3%
2025	6,580,868	3.0%
2030	6,746,762	2.5%

Source: US. Census Bureau

Based on these projections the following counties will be expected to experience a population decrease of 5 percent or greater by 2020.

Table 3.4n Counties Projected to Have Future Population Decreases - (In order of percent decline by 2020)

Counties	2010	Population Projections					
		2020 (Proj)	2030 (Proj)	% Decline by 2020	% Decline by 2030	# Decline by 2020	# Decline by 2030
New Madrid County	18,956	14,621	12,554	-16.87%	-28.63%	2,968	5,035
Gentry County	6,738	5,314	4,759	-14.08%	-23.06%	871	1,426
Iron County	10,630	8,605	7,494	-13.24%	-24.44%	1,313	2,424
Chariton County	7,831	6,832	6,172	-11.73%	-20.26%	908	1,568
Holt County	4,912	4,428	4,094	-9.72%	-16.53%	477	811
Mississippi County	15,607	12,285	11,443	-9.03%	-15.26%	1,219	2,061
Sullivan County	6,714	6,033	5,822	-8.99%	-12.17%	596	807
Linn County	12,761	11,477	10,696	-8.77%	-14.98%	1,103	1,884
Mercer County	3,523	3,221	3,142	-8.57%	-10.81%	302	381
Atchison County	5,685	5,559	5,280	-7.83%	-12.45%	472	751
Texas County	26,008	22,684	22,169	-7.78%	-9.87%	1,914	2,429
Putnam County	4,979	4,545	4,391	-6.52%	-9.69%	317	471
Pemiscot County	18,296	17,324	16,447	-6.43%	-11.17%	1,191	2,068
Worth County	2,171	1,917	1,826	-5.98%	-10.45%	122	213
Carroll County	9,295	9,232	8,816	-5.37%	-9.64%	524	940
Shelby County	6,373	6,067	5,764	-5.37%	-10.09%	344	647
Wayne County	13,521	12,001	11,200	-5.15%	-11.48%	651	1,452
Dunklin County	31,953	29,870	28,765	-5.04%	-8.55%	1,584	2,689
Missouri Statewide	5,988,927	6,389,850	6,746,762	8.09%*	14.13%*	N/A	N/A

Source: US. Census Bureau; *Note, Statewide populations are expected to increase.

Housing Units

Another indicator of growth is number of housing units. The census defines a housing unit as a house, an apartment, a mobile home or trailer, a group of rooms, or a single room that is occupied, or, if vacant, is intended for occupancy as separate living quarters. According to the U.S. Census Bureau, the number of housing units in Missouri increased 9.9 percent (2,712,729 units) between 2000 and 2010. Missouri ranked 18th among the 50 states in number of housing units and 18th in total population). Taney County topped the list for percent growth and was the 59th fastest growing county in the nation in terms of housing units in the 2010 Census.

Table 3.4o and Table 3.4p list the counties that have grown the most in terms of housing units by number and percent respectively. Figure 3.4.5 and Figure 3.4.6 illustrate these changes statewide.

Table 3.4o Counties with Greatest Estimated Housing Unit Gains (Numerical), 2000-2010

County	Housing Unit Increase	Percent Increase Housing Unit
St. Charles	35,502	25.18%
Jackson	23,874	7.65%
Greene	20,870	16.64%
Clay	17,688	18.83%
St. Louis County	14,283	3.26%
Boone	12,873	18.51%
Jefferson	12,040	13.74%
Christian	9,749	30.87%
Taney	9,567	32.70%
Cass	8,353	20.87%

Source: U.S. Census Bureau, 2010

Table 3.4p Counties with Greatest Estimated Housing Unit Gains (Percent), 2000-2010

County	Percent Increase Housing Unit	Housing Unit Increase
Taney	32.70%	9,567
Christian	30.87%	9,749
Lincoln	26.18%	5,500
St. Charles	25.18%	35,502
Warren	24.78%	3,639
Platte	21.21%	8,321
Cass	20.87%	8,353
Stone	20.28%	4,132
Clay	18.83%	17,688
Camden	18.73%	7,713

Source: U.S. Census Bureau, 2010

Figure 3.4.5 - Change in Housing Units by County, 2000 – 2010

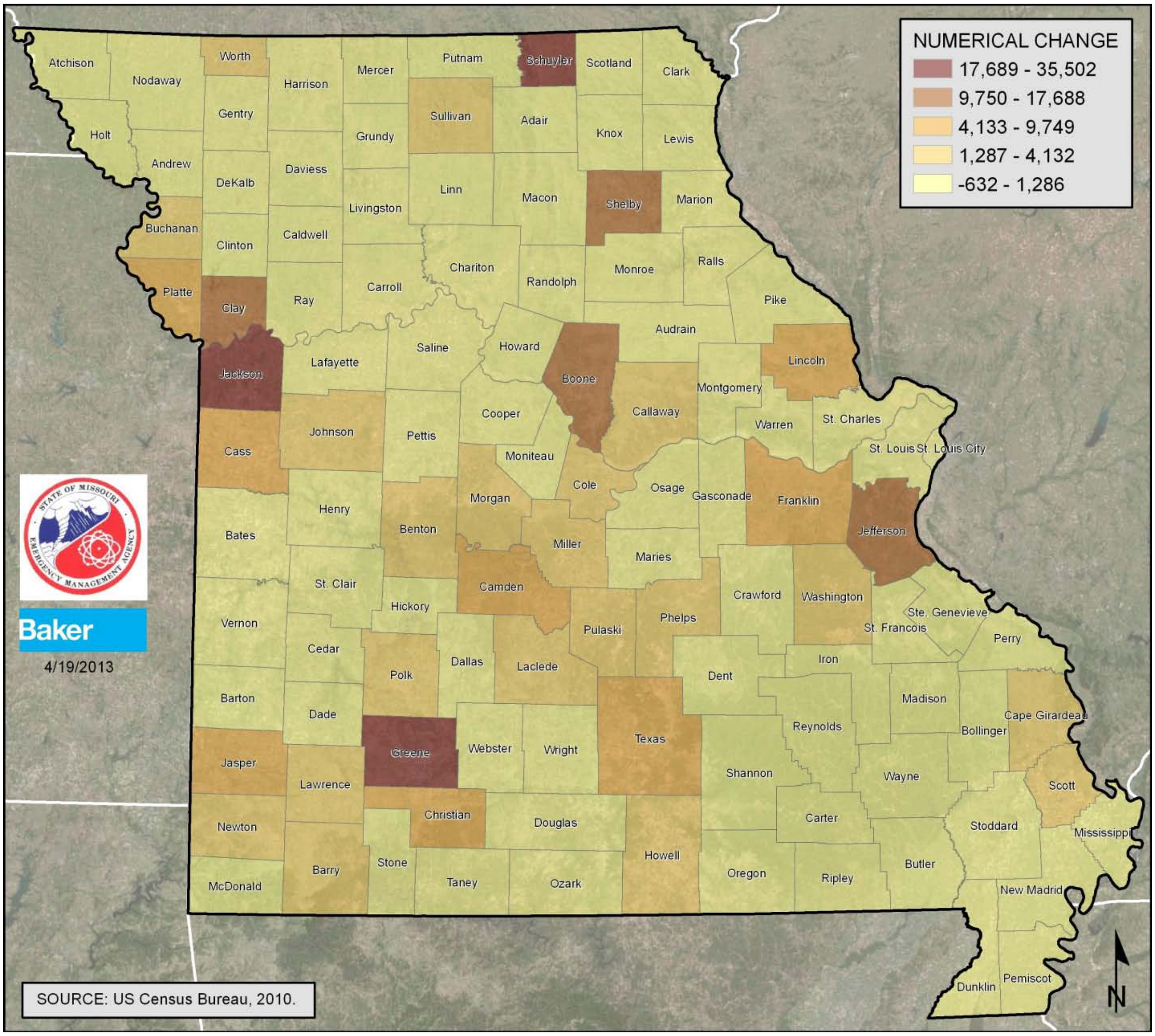
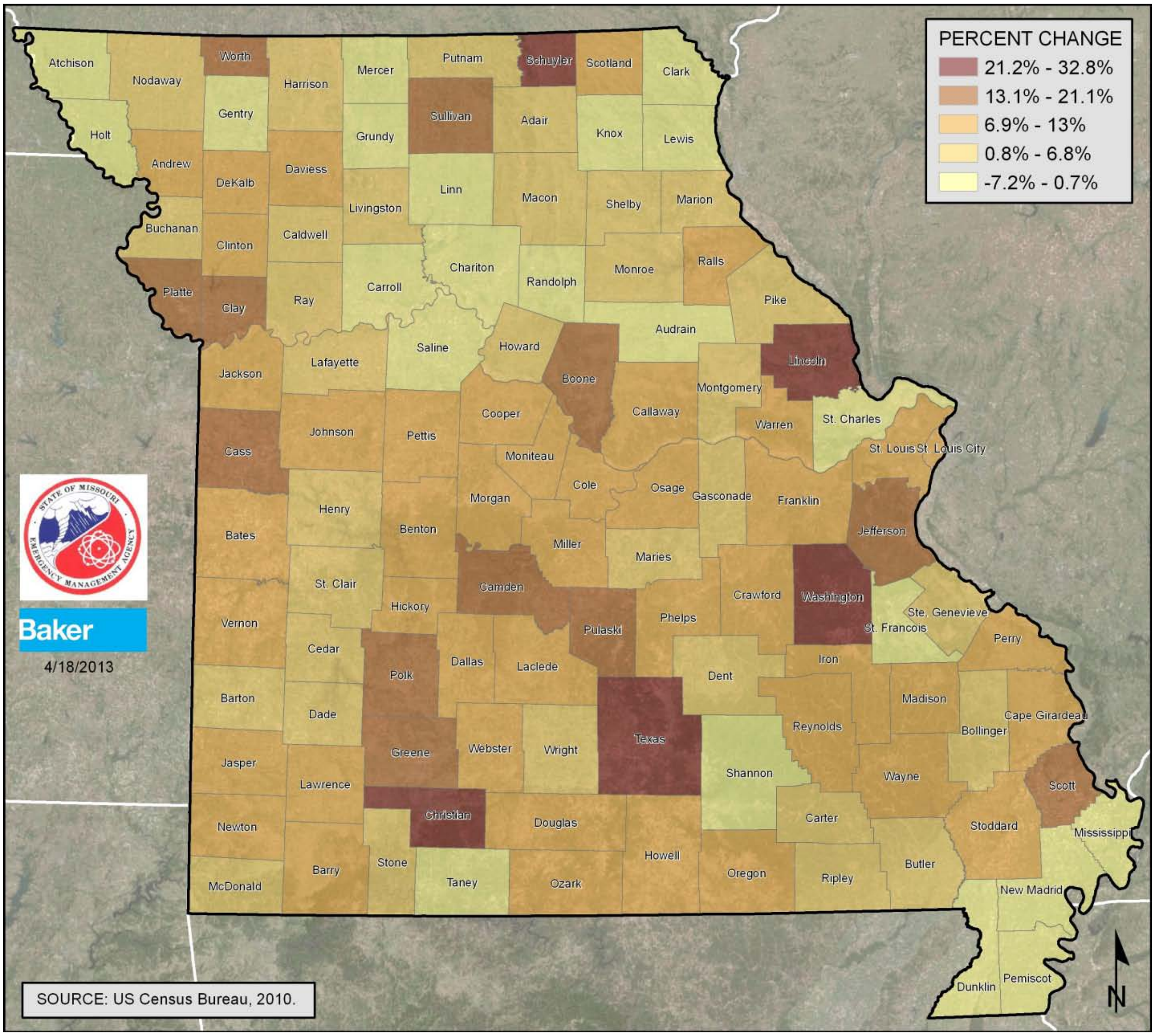


Figure 3.4.6 - Percent Change in Housing Units by County, 2000 - 2010



As illustrated in Table 3.4q, the 10 most populous counties also have the most housing units. Housing unit growth also tracks with population growth, but not quite as closely.

Table 3.4q Top 10 Counties Ranked by Number of Housing Units (2010)

County	2010 Housing Units	2010 Population
St. Louis	438,032	998,954
Jackson	312,105	674,158
St. Louis City*	176,002	319,294
St. Charles	141,016	360,485

County	2010 Housing Units	2010 Population
Greene	125,387	275,174
Clay	93,918	221,939
Jefferson	87,626	218,733
Boone	69,551	162,642
Jasper	50,668	117,404
Franklin	43,419	101,492

Source: U.S. Census Bureau, 2010

Density

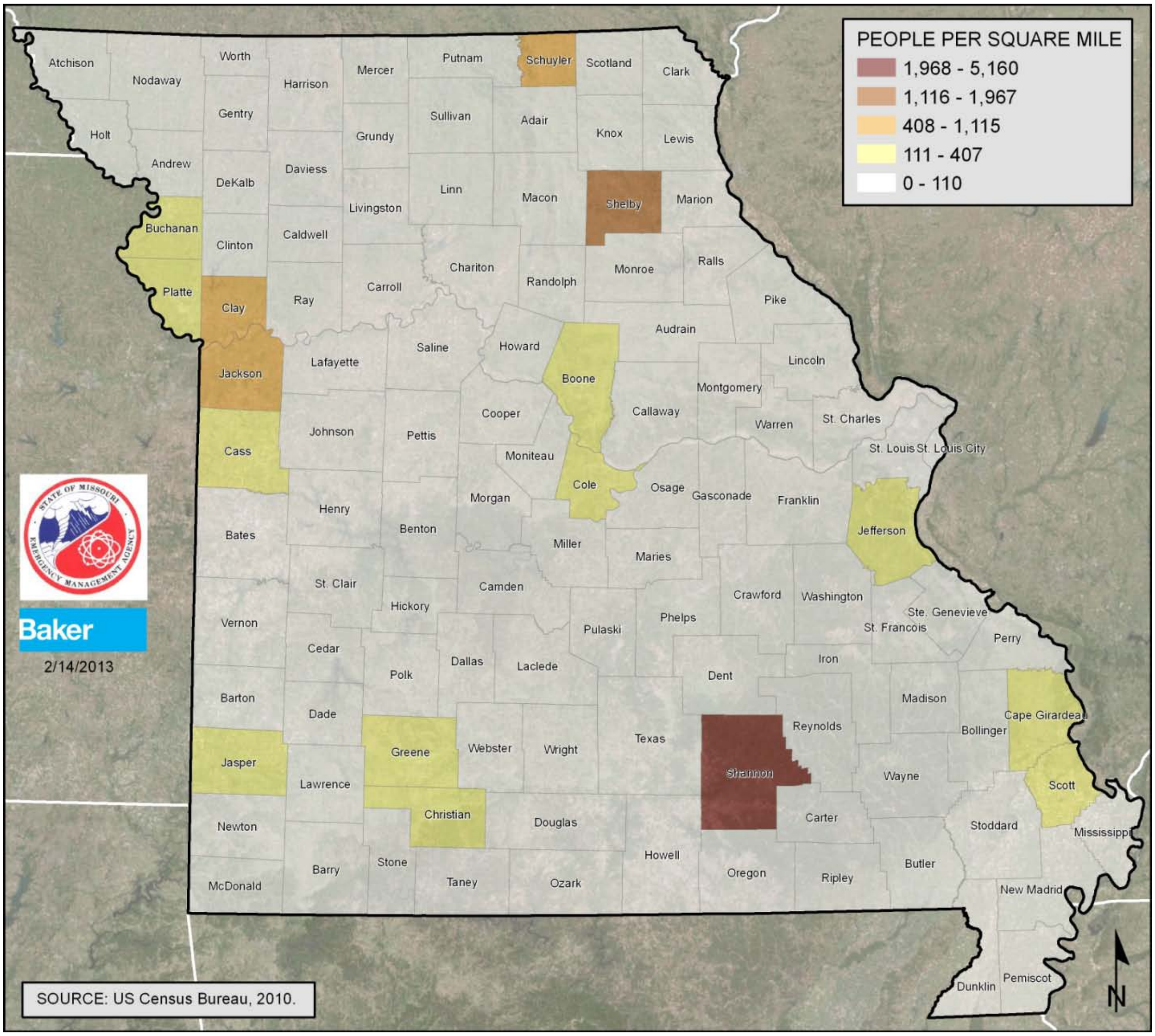
Missouri has a surface land area of 68,741 square miles (2010 census) and a population of 5,988,927 (2010 Census). Based on the 2010 census, Missouri ranked 28th in population density and 27th in housing density among the 50 states. The same 10 counties ranked at the top in terms of both population density and housing density (see Table 3.4r). Eight of these counties (excluding Buchanan and Platte) also ranked among Missouri's top 10 most populous counties. Figure 3.4.7 illustrates density by statewide.

Table 3.4r Top 10 Counties Ranked by Population/Housing Density, 2010

County	2010 Population Density*	Population Density* Change (%) 2000-2010	2010 Housing Density*	Housing Density* Change (%) 2000-2010
St. Louis* City	5157.0	-8.90%	2842.9	-0.18%
St. Louis County	1967.0	-1.71%	862.6	3.26%
Jackson	1115.0	2.76%	516.3	7.71%
St. Charles	643.2	21.19%	251.6	25.16%
Clay	558.6	17.03%	236.4	18.65%
Greene	407.5	12.60%	185.7	16.64%
Jefferson	333.1	9.48%	133.4	13.72%
Boone	237.3	16.67%	101.5	18.52%
Buchanan	218.6	3.58%	94.2	5.20%
Platte County	212.6	17.37%	93.3	21.22%

Sources: U.S. Census Bureau,
Notes: *Density is reported as people/housing units per square mile and is based on the square mileage of the counties in the 2010 census
**St. Louis City* is considered both a "place" and a "county" by the U.S. Census Bureau, so it is treated here as a as well as a city

Figure 3.4.7 - Population Density by County, 2010



The percent change in population density tracks with the percent change in population growth. The fastest growing counties are also seeing their population density increase more rapidly than the other counties (see Table 3.4s and Figure 3.4.8).

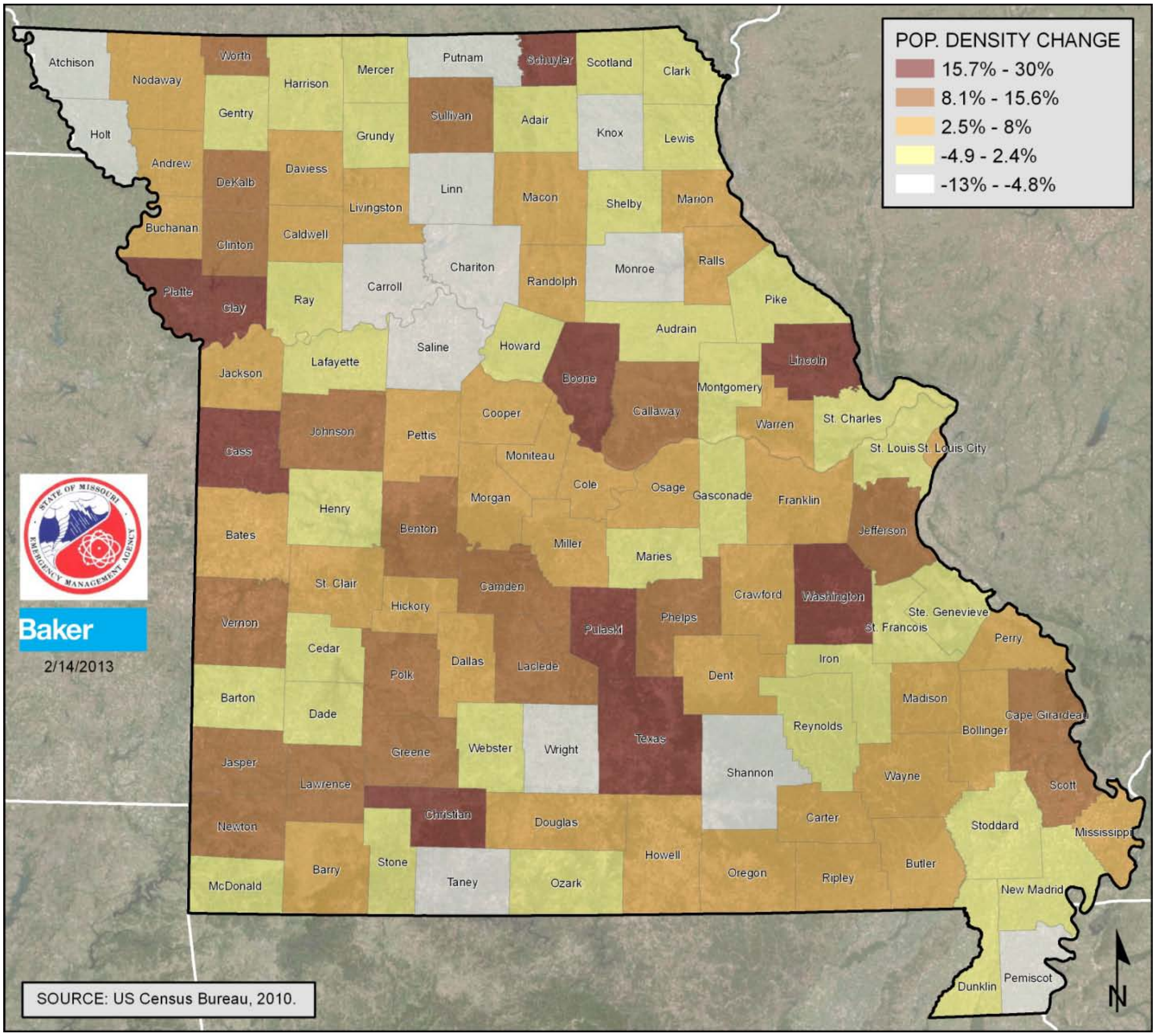
Table 3.4s Counties with Greatest Estimated Population Density Gains (Percent), 2000-2010

County	Population Density* Gains (%) 2000-2010
Christian	42.60%
Lincoln	35.00%

County	Population Density* Gains (%) 2000-2010
Warren	32.60%
Taney	30.20%
Pulaski	27.00%
St. Charles	27.0%
Cass	21.20%
Platte	21.10%
Clay	20.60%
Boone	20.10%

Sources: U.S. Census Bureau, 2010
Note:
*Density is reported as people per square mile and is based on the square mileage of the counties in the 2010 census.

Figure 3.4.8 - Percent Change in Population Density by County, 2000-2010



Summary of Impact of Growth and Development Trends on Vulnerability and Loss Estimates

In general, counties with growing populations and number of housing units will have increased vulnerability to random events such as tornadoes and winter storms. Extreme southeastern Missouri counties are experiencing little (less than 5 percent) or no growth, thus the earthquake vulnerability to those populations has not changed significantly between 2000 and 2010. The counties experiencing the most development pressures all participate in the National Flood Insurance Program, thus flood risk should not be increasing in these counties; assuming that floodplain ordinances are being effectively implemented and wise use of floodplains is being encouraged.

Social Vulnerability

A Social Vulnerability Index compiled by the Hazards and Vulnerability Research Institute in the Department of Geography at the University of South Carolina measures the social vulnerability of U.S.

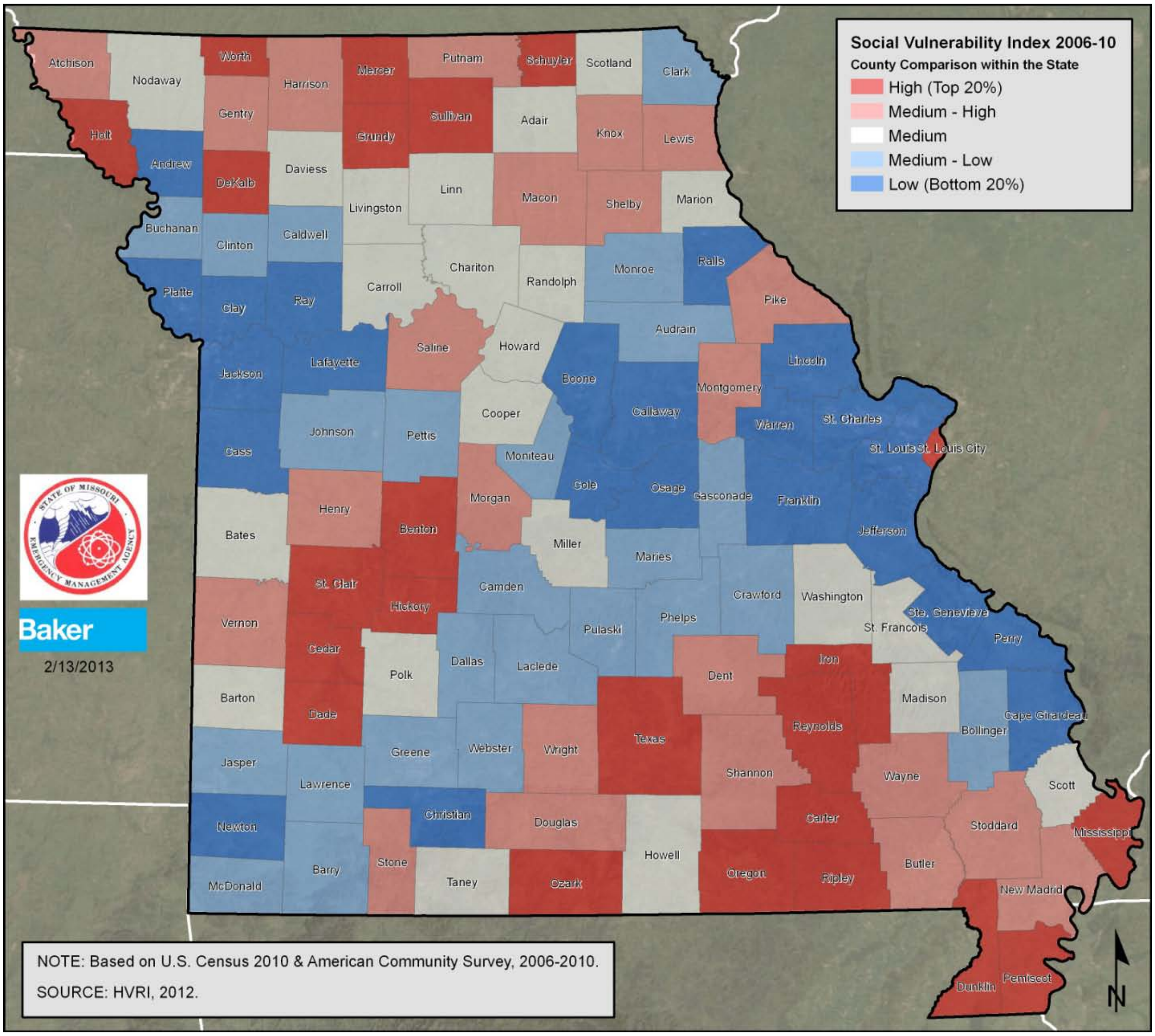
counties to environmental hazards for the purpose of examining the differences in social vulnerability among counties. Based on national data sources, primarily the 2010 census, it synthesizes 42 socioeconomic and built environment variables that research literature suggests contribute to reduction in a community's ability to prepare for, respond to, and recover from hazards (i.e., social vulnerability). Eleven composite factors were identified that differentiate counties according to their relative level of social vulnerability: personal wealth, age, density of the built environment, single-sector economic dependence, housing stock and tenancy, race (African American and Asian), ethnicity (Hispanic and Native American), occupation, and infrastructure dependence.

The index can be used by the State to help determine where social vulnerability and exposure to hazards overlaps and how and where mitigation resources might best be used. See Figure 3.4.9 for a map that illustrates Missouri's geographic variation in social vulnerability. According to the index, the following, listed in order, are Missouri's most vulnerable counties (i.e., they rank in the top 20 percent in the State—and the nation): Pemiscot, Mississippi, Iron, Reynolds, DeKalb, Benton, Dunklin, Dade, Hickory, St. Louis City*, Grundy, Cedar, Ozark, Ripley, Carter, Worth, Sullivan, Texas, Oregon, Mercer, St. Clair, Schuyler, and Holt.

The counties of Vernon, Gentry, Harrison, New Madrid, and Knox are close behind and also rank in the top 20 percent in the nation.

Between 2000 and 2010, subtle vulnerability changes occurred. The most noticeable change occurred along the Missouri River county boundary. Many of the counties that border the Missouri River decreased in vulnerability. Additionally, High vulnerability areas seemed to have migrated to the southern part of the state.

Figure 3.4.9 - Social Vulnerability to Environmental Hazards, Comparison within the State, 2010



3.5 Vulnerability Analysis and Estimating Potential Losses by Jurisdiction: State Risk Analysis

Requirements §201.4(c)(2)(ii) and §201.4(c)(2)(iii):	[The state risk assessment shall include an] overview and analysis of the state's vulnerability to the hazards described in this paragraph (c)(2), based on estimates provided in local risk assessments as well as **the State risk assessment.** The state shall describe vulnerability in terms of the jurisdictions most threatened by the identified hazards, and most vulnerable to damage and loss associated with hazard events. [The state risk assessment shall include an] overview and analysis of potential losses to identified vulnerable structures, based on estimates provided in local risk assessments as well as **the State risk assessment.**
Update §201.4(d):	Plan must be reviewed and revised to reflect changes in development.

According to FEMA's risk assessment guidance (FEMA 386-2) vulnerability is defined as being open to damage or attack. Risk is defined as the possibility of loss or injury. This section details the vulnerability and risk that Missouri counties face from the hazards identified in Section 3.2 and Profiled in Section 3.3. In the 2007 plan update, the State prioritized resources toward analyzing vulnerability and estimating losses from the significant hazards of flood, earthquake, and tornado including a major effort to quantify flood losses statewide using Hazus, as well as improved tornado and earthquake risk assessments.

For the 2010 update, the State increased the accuracy of the Hazus risk assessment for flood by integrating available DFIRM depth grids into the Hazus for 28 Missouri Counties and the independent City of St. Louis. In addition, for that update, the State applied vulnerability and risk assessment methodologies to quantify losses for the other profiled hazards where data was available.

For the 2013 update, the state continued to enhance the accuracy of the Hazus risk assessment for flood by integrating available DFIRM depth grids into Hazus for 79 counties and the City of St. Louis (this includes the 28 that were incorporated during the previous update). These depth grids were produced utilizing, where possible, enhanced LiDAR topographic data. Additionally, the state-wide inventory database was enhanced through the use of updated Census data (2010) as well as the Department of Homeland Security's Homeland Security Infrastructure (HSIP) essential facility data, for both improved flood and earthquake Hazus assessments. Vulnerability and risk assessment methodologies were updated and altered as necessary in an effort to accurately quantify losses for the other profiled hazards as well. Table 3.5a summarizes the updates in the section for each hazard profiled.

Table 3.5a Summary of Vulnerability Analysis/Loss Estimation Updates

Natural Hazards	2007	2010	2013
Riverine Flooding (Major and Flash)	HAZUS-MH	HAZUS-MH and DFIRM modeled Floodplain Boundaries (integrated DFIRM depth grids for 29 counties); Base flood (100-year);HAZUS-MH MR4 with 10 sq mile minimum stream drainage area and 30 m USGS Digital Elevation Models for terrain;	Hazus 2.1 level 2 hazard modeling and loss estimation utilizing Hazus and DFIRM floodplain boundaries (where available); created depth grids from DFIRM floodplain boundaries using available LIDAR data and 10 Meter USGS NED grids

Natural Hazards	2007	2010	2013
Dam Failure	None	GIS Modeling of All Dams, State-regulated dams; analysis for all State-regulated dams based on State Hazard Class(1, 2, or 3) definitions and U.S. Census data on average structure value and household size	GIS analysis for all State-regulated dams based on State Hazard Class (1, 2, or 3) definitions, number of vulnerable buildings, average structure value and household size using U.S. Census data, and Missouri DNR high risk dam inundation zones.
Levee Failure	None	Analysis of DFIRM data to determine loss estimates for 2 PAL/Accredited levees (limited by available data); Analysis of USACE data for levees in USACE Levee Safety Program	Analysis of MLI and NLD data to determine loss estimates for all levees known to provide protection against 100-year flood.
Earthquakes	HAZUS-MH	HAZUS-MH 2500-year annualized loss scenario and event with 2% Probability of Exceedence in 50 Years	Hazus2.1 level 2 hazard modeling and loss estimation of an average annualized loss scenario and event with a 2% probability of exceedance in 50 years (modeling worst case scenario)
Land Subsidence /Sinkholes	None	GIS Modeling of Sinkhole and Mine locations in Missouri from the Department of Natural Resources	Updated GIS modeling of sinkhole and mine locations in Missouri from the Department of Natural Resources.
Severe Thunderstorms	None	Statistical analysis of NCDC data available for hail, lightning, and wind 1993 to July 2009; HAZUS MH-MR4 exposure values; U.S. Census housing and population; and 10-year USDA crop insurance claims for hail and wind.	Analysis was completed of the most recent storm data available from the NCDC on hail, lightning and wind form 1993 – September 2012. US Census housing and population data was updated. *USDA crop insurance data is still being compiled federally*
Tornadoes	Statistical analysis of NCDC data	Update to statistical analysis of NCDC data incorporating recent events and changes in housing and population	Update to statistical analysis of NCDC data incorporating recent events, Hazus 2.1 exposure values, and U.S. Census data.
Severe Winter Weather/Snow/Ice: North of MO River South of MO River	None	Statistical analysis of NCDC data FEMA Public Assistance payments 1993 to July 2009; HAZUS MH-MR4 exposure values; U.S. Census housing and population; and 10-year USDA crop insurance claims/	Analysis was completed on updated NCDC data, as well as FEMA public assistance payments. Housing exposure values were generated through HAZUS. *USDA crop information is still being compiled at the federal level, and not yet available*
Drought	None	Incorporation of vulnerability studies in the Missouri Drought Plan and Statistical analysis of 10-year USDA crop insurance claims resulting from drought and crop exposure values from USDA	Incorporation of vulnerability studies in the Missouri Drought Plan and updated statistical analysis of 10-year USDA crop insurance claims resulting from drought and crop exposure values from USDA.
Extreme Temperatures	None	Analysis of statistical data from Missouri Department of Health and Senior Services for hyperthermia mortality in Missouri	Updated analysis of statistical data from Missouri Department of Health and Senior Services for hyperthermia mortality in Missouri.

Natural Hazards	2007	2010	2013
Fires: Structural & Urban Wild	None	Structural & Urban: Statistical analysis of 5-year National Fire Incident Reporting System (NFIRS) records; HAZUS MH-MR4 exposure values; U.S. Census housing and population Wildfire: Statistical analysis of 5-year Department of Conservation wildfire records	Structural & Urban: Statistical analysis of updated National Fire Incident Reporting System (NFIRS) records; Hazus 2.1 exposure values; U.S. Census housing and population. Wildfire: Statistical analysis of updated Department of Conservation wildfire records.

Manmade and Other Hazards	2007	2010	2013
CBNRE Attack	None	Hypothetical Scenario-based Estimates	Hypothetical Scenario-based Estimates
Civil Disorder	None	Hypothetical Scenario-based Estimates	Hypothetical Scenario-based Estimates
Cyber Disruption	N/A	N/A	Hypothetical Scenario-based Estimates
Hazardous Materials Release: Fixed facility accidents Transportation accidents	None	Statistical analysis of Hazardous Materials Incidents reported to the Missouri Environmental Emergency Response Tracking System (MEERTS) database for railroad/railyard incidents, fixed facility incidents, and agricultural facility incidents	Updated statistical analysis of Hazardous Materials Incidents reported to the Missouri Environmental Emergency Response Tracking System (MEERTS) database for railroad/rail yard incidents, fixed facility incidents, and agricultural facility incidents.
Mass Transportation Accidents	None	Hypothetical Scenario-based Estimates	Updated hypothetical scenario-based estimates
Nuclear Power Plants (Emergencies and Accidents)	None	Hypothetical Scenario-based Estimates	Hypothetical Scenario-based Estimates
Public Health Emergencies/Environmental Issues	None	Statistical Analysis utilizing planning assumptions from the Department of Health and Senior Services; US Census population; and average hospital charges from the Missouri Hospital Association's Hospital Industry Data Institute	Updated statistical analysis utilizing planning assumptions from the Department of Health and Senior Services; US Census population; and average hospital charges from the Missouri Hospital Association's Hospital Industry Data Institute
Special Events	None	Hypothetical Scenario-based Estimates	Hypothetical Scenario-based Estimates
Terrorism	None	Hypothetical Scenario-based Estimates	Hypothetical Scenario-based Estimates
Utilities (Interruptions and System Failures)	None	Statistical Analysis utilizing FEMA standard values and U.S. Census population to determine loss of use values for water, wastewater, and electric utilities	Updated statistical analysis utilizing FEMA standard values and U.S. Census population to determine loss of use values for water, wastewater, and electric utilities

This section of the risk assessment will be based on the **State risk assessment** and will include the following for each hazard identified and profiled in Section 3.2 and Section 3.3.

1) **Overview and Analysis of Vulnerability to Hazards**: This section will be discussed for each hazard and will provide an overview and analysis of the State's *vulnerability* to the hazards which will serve to describe vulnerability in terms of the jurisdictions most threatened by the

identified hazards, and most vulnerable to damage and loss associated with hazard events. The overview vulnerability analysis was completed using a variety of methods, including, Hazus, other GIS-based risk modeling, statistical analysis of exposure, census data, and past historic losses.

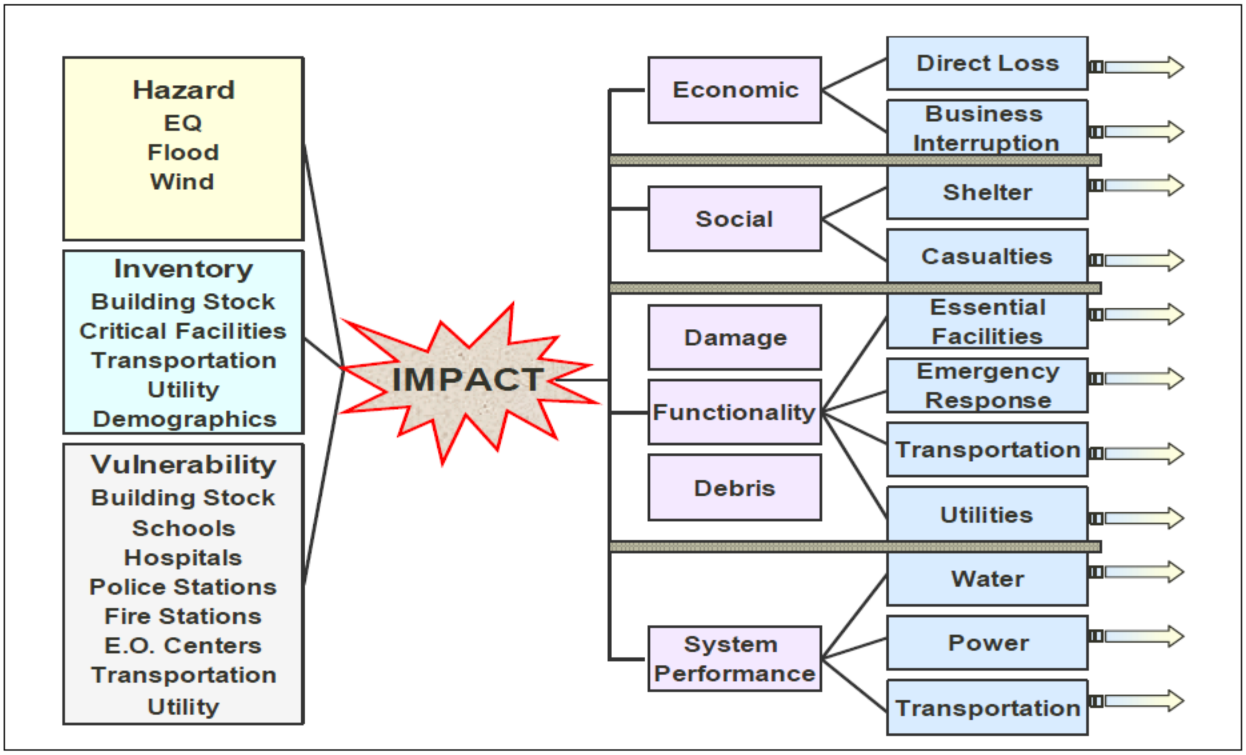
2) **Overview and Analysis of Potential Loss Estimates**: Where data is available, this overview and analysis of *potential losses* to the identified vulnerable structures is provided utilizing a combination of Hazus, other GIS-based risk modeling, statistical analysis of past historic losses, and hypothetical scenario-based estimates. The methods utilized are described in greater detail for each hazard where data is available. For those hazards for which data is not available, the limitations which preclude analysis of potential losses will be described.
3) **Changes in Development for Jurisdictions in Hazard Prone Areas:** Where applicable, changes in development will be discussed as they pertain to identified hazard-prone areas.

Loss estimates provided herein are based on available data, and the methodologies applied resulted in an approximation of risk. These estimates are used to understand relative risk from hazards and potential losses. Uncertainties are inherent in any loss-estimation methodology, arising in part from incomplete observed data and scientific knowledge concerning natural hazards and their effects on the built environment. Uncertainties also result from approximations and simplifications that are necessary for a comprehensive analysis (such as incomplete inventories, demographics, or economic parameters).

Hazus Loss Estimation Methodology

Hazus is FEMA's standardized loss-estimation software program built upon an integrated geographic information system platform (see Figure 3.5.1). The Hazus risk assessment methodology is parametric in that distinct hazard, vulnerability, and inventory parameters (earthquake spectral ordinates, building construction, and building classes) were modeled using the Hazus 2.1 software to determine the impact on the built environment (damage and losses). This risk assessment applied Hazus to produce regional profiles and estimate losses for two hazards: earthquakes and riverine flooding.

Figure 3.5.1 - Conceptual Model of Hazus Methodology



GIS-based Risk Modeling

For some hazards such as dam failure and land subsidence, geographic locations of areas at risk to the hazard are known. However, these hazards are outside the scope of Hazus. For these hazards, the known locations of areas at risk are mapped utilizing geographic information systems to show areas of the State that are at greatest risk.

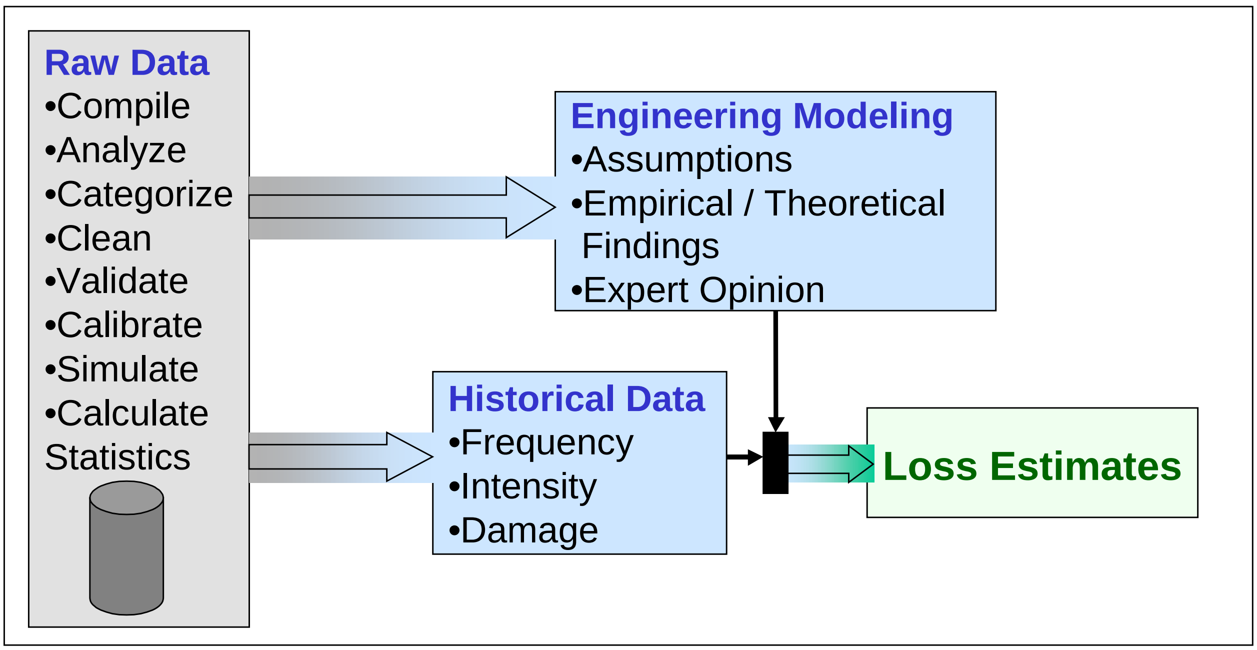
Statistical Risk Assessment Methodology

The statistical risk assessment methodology was applied to analyze hazards of concern that are outside the scope of Hazus or other GIS-based risk-modeling. This approach is based on different principals than Hazus and does not rely on readily available automated software. It uses a statistical approach and mathematical modeling of risk to predict a hazard's frequency of occurrence and estimated impacts based on recorded or historic damage information. Historical data for each hazard are used and statistical evaluations are performed using manual calculations. Figure 3.5.2 illustrates a conceptual model of the statistical risk assessment methodology. The general steps used in the statistical risk assessment methodology are summarized below:

- Compile data from national and local sources;
- Conduct statistical analysis of data to relate historical patterns within data to existing hazard models (minimum, maximum, average, and standard deviation);
- Categorize hazard parameters for each hazard to be modeled;
- Develop model parameters based on analysis of data, existing hazard models, and risk engineering judgment ;

- Apply hazard model including:
  - Analysis of frequency of hazard occurrence
  - Analysis of intensity and damage parameters of hazard occurrence
  - Development of intensity and frequency tables and curves based on observed data
  - Development of simple damage function to relate hazard intensity to a level of damage (e.g., one flood = $ in estimated damage)
  - Development of exceedence and frequency curves relating a level of damage for each hazard to an annual probability of occurrence
  - Development of annualized loss estimates.

Figure 3.5.2 - Conceptual Model of the Statistical Risk Assessment Methodology



Hypothetical Scenario-based Estimates

Specific scenario-based loss estimates are provided for several of the manmade and other hazards of concern that are outside the scope of Hazus, GIS-based risk-modeling, and statistical analysis. For these hazards information on historical losses was not available. In addition since there are so many variables involved with manmade hazards, it is difficult to make generalized assumptions for future events. In these instances, the planning team chose to analyze specific scenarios to establish an acceptable loss estimation methodology.

Economic Impact

Risk assessment is presented for annualized losses, whenever possible. In general, presenting results in the annualized form is very useful for three reasons: 1) Contribution of potential losses from all (long term) future disasters is accounted for with this approach; 2) Results in this form for different hazards are readily comparable and hence easier to rank; and 3) When evaluating mitigation alternatives, use of annualized losses is an objective approach.

The economic loss results are presented here using two interrelated risk indicators: 1) The annualized expected loss (AEL), which is the estimated expected long-term value of losses to the general building stock for a specified geographic area (i.e., county) and 2) The annualized loss ratio (ALR), which expresses estimated annualized loss as a fraction of the building inventory replacement value

The estimated AEL addresses key components of risk: the probability of a hazard event occurring in the study area, the consequences of the event (largely a function of building construction type and quality), and the intensity of the event. By annualizing estimated losses, the AEL factors in historic patterns of frequent small events with infrequent larger events to provide a balanced presentation of the risk. In Hazus, losses are annualized for earthquake return periods of 100, 250, 500, 750, 1,000, 1,500, 2000, and 2,500 years.

The ALR represents the AEL as a fraction of the replacement value of the local building inventory. It gauges the relationship between average annualized loss and building replacement value. This ratio can be used as a measure of relative risk between areas and, since it is normalized by replacement value, it can be directly compared across different geographic units such as metropolitan areas or counties. It can also be used as a measure of community sustainability following a disaster.

Annualized losses for the hazards where the parametric approach is used are computed automatically using a probabilistic approach. For hazards where the statistical approach was used, the computations are based primarily on the observed historical losses.

3.5.1 Riverine Flooding (Major and Flash)

For hazard profile information for riverine flooding, see Section 3.3.8.

Overview and Analysis of Vulnerability to Flooding

The vulnerability of Missouri to flooding is significant. During the 2007 plan update, the State used the most recent release of Hazus MR2 to model flood vulnerability and flood losses for every Missouri county and the City of St. Louis.

For the 2010 update, the State enhanced the flood vulnerability/loss estimation capability of Hazus MR4 by integrating Digital Flood Insurance Rate Map (DFIRM) depth grids for 28 Missouri counties and the City of St. Louis. These enhanced data inputs allowed Hazus to more accurately approximate the floodplain boundaries and associated depth grids for the 1-percent-annual-chance-flood event (also referred to as the Base Flood, the 100-year flood, or the Special Flood Hazard Area [SFHA]). The Hazus analysis performed on those 29 jurisdictions is termed 'Level 2' analysis, as improved local data sets were utilized to enhance the resulting vulnerability and loss estimations. For the other 86 counties where more detailed DFIRM depth grids were not available, no additional or updated Hazus analysis was performed. In these cases, the results from the 2007 Hazus MR2 analysis were re-used.

For the 2013 update, the State further enhanced the flood vulnerability assessment and loss estimation capabilities of Hazus by leveraging a number of improved local data inputs. This was first achieved by integrating DFIRM depth grids for 51 additional counties. In addition, the State re-analyzed the previous 29 depth grids used in 2010, to utilize the latest enhancements available in Hazus 2.1. This brought the total number of regions analyzed using DFIRM depth grids to 80 jurisdictions (79 counties and the City of St. Louis - see Figure 3.5.1.1 on the next page. The second set of improved data inputs included an enhanced building inventory database, which is an improvement over the standard Hazus 2.1 stock data. That data, coupled with the DFIRM depth grids, enabled Level 2 Hazus flood analysis for all 114 counties as well as the City of St. Louis.

Figure 3.5.1.1 - DFIRM Integration vs. Original Hazus Analysis

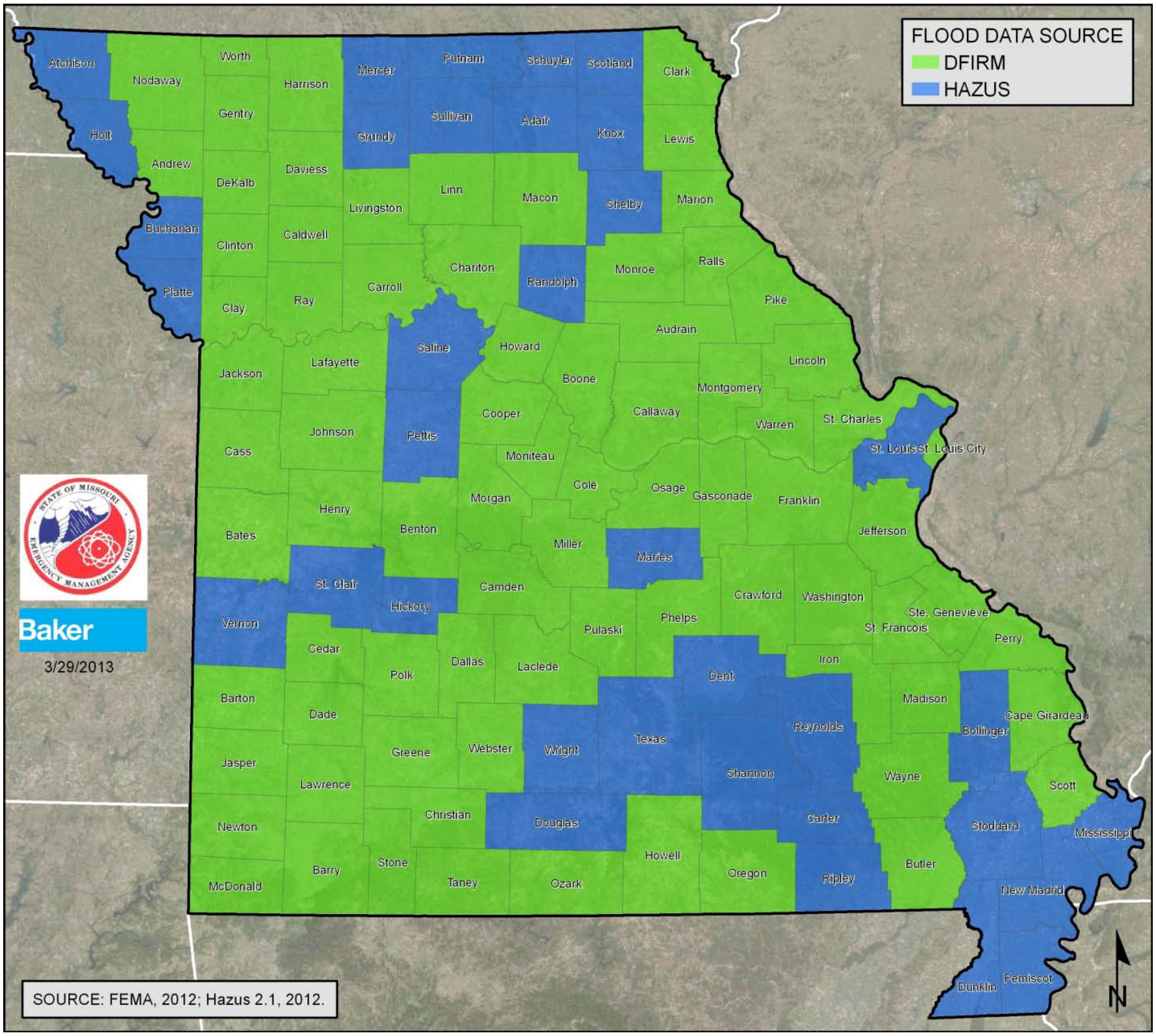


Figure 3.5.1.2 shows the 100-year floodplain boundaries for each of the 114 counties and the City of St. Louis. It is evident that those floodplains derived from DFIRM data are more comprehensive and accurate than those produced entirely by Hazus, which will result in more accurate vulnerability and loss estimations. The hydrology and hydraulics model used to produce the DFIRM floodplains creates streams based on <1 sq. mile drainage areas, while the Hazus model uses a 10 sq. mile drainage area. The smaller drainage area in the model generates more streams per unit area. As an example, Figure 3.5.1.3 that follows shows a graphical comparison between a DFIRM floodplain and a Hazus-generated floodplain data for Crawford County.

Figure 3.5.1.2 - DFIRM and Hazus Countywide Base-Flood Scenarios: Modeled Floodplain Boundaries

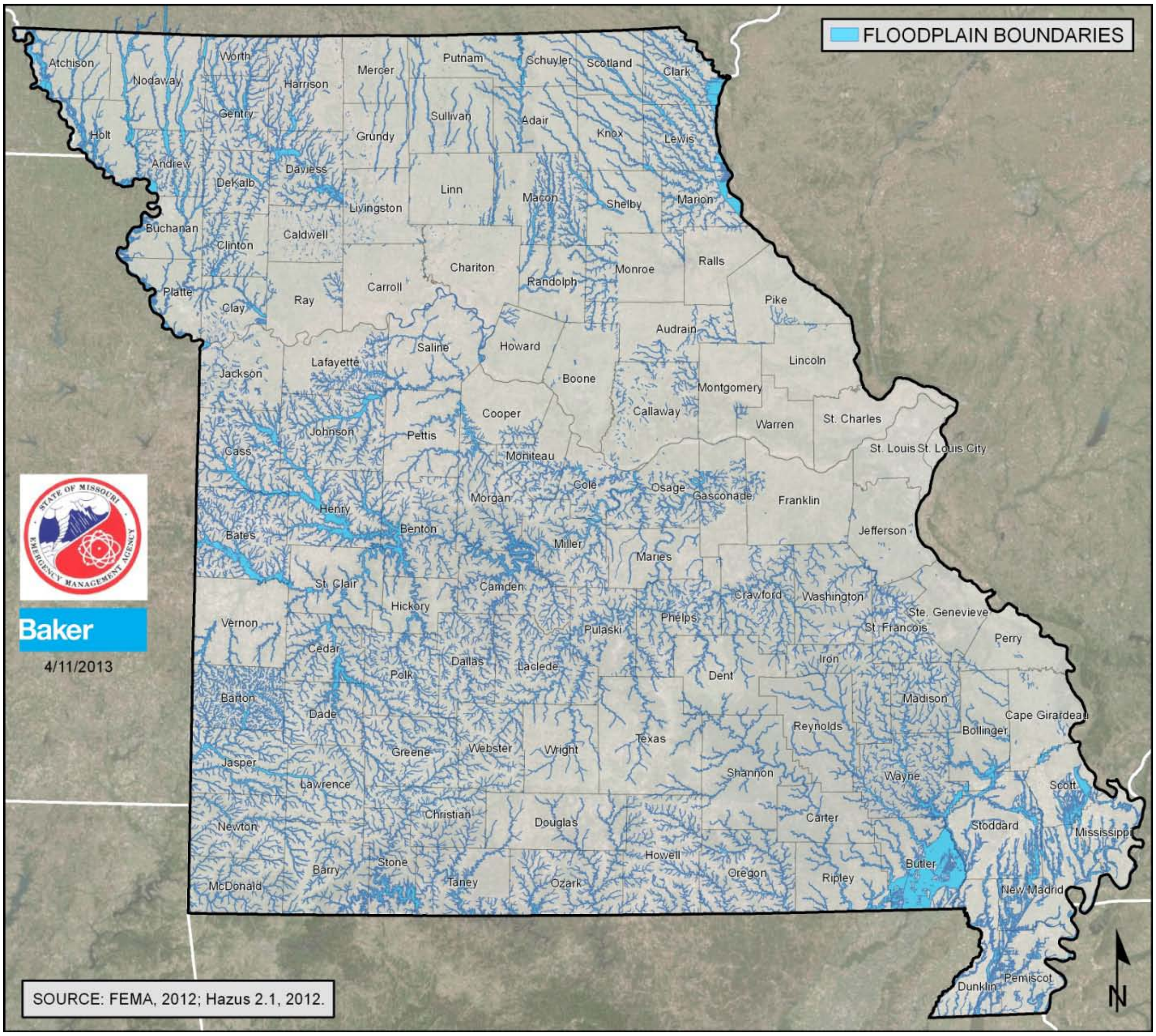
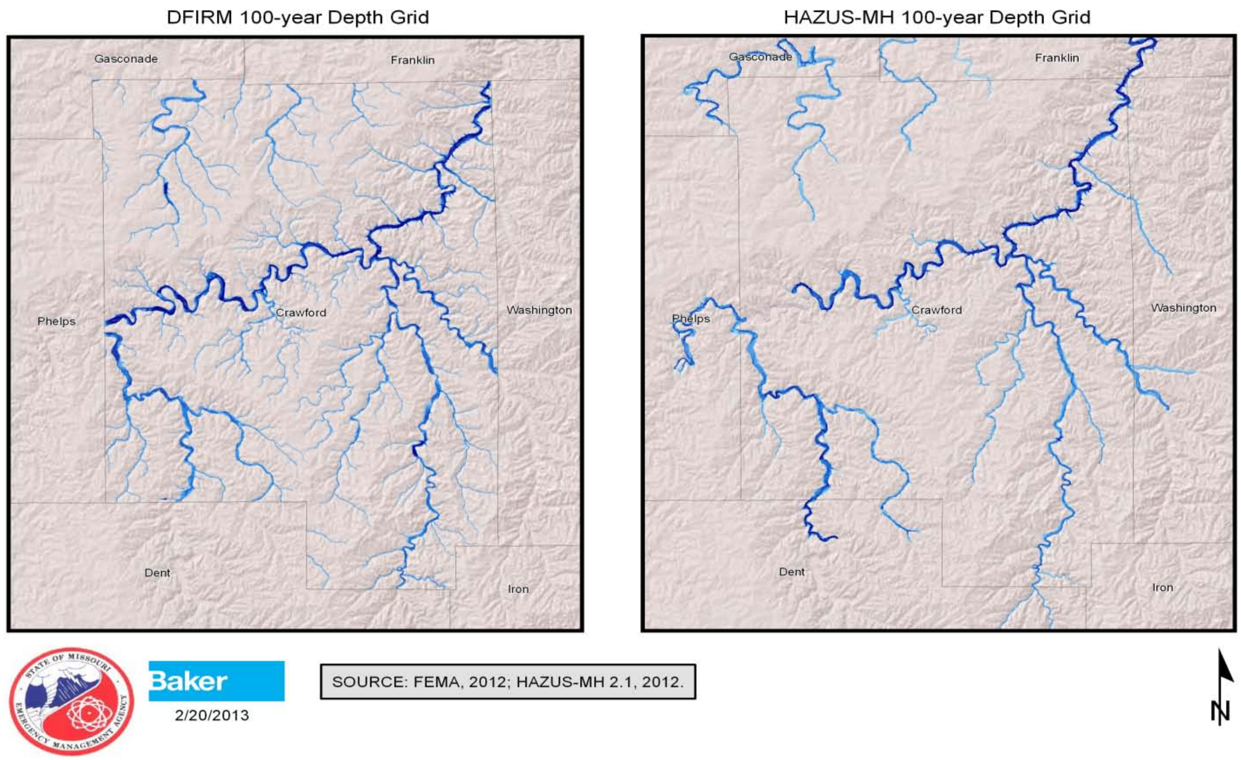


Figure 3.5.1.3 - Crawford County: DFIRM and Hazus 100-year Flood



The Hazus flood analysis was a significant undertaking for the State for the 2013 State Plan Update. Producing a Hazus flood run is very computer resource intensive. Processing a single county takes an average of 8 hours from start to finish, depending on the size of the county, density of the stream network, and density of census blocks.

To develop countywide probabilistic analyses for the non-DFIRM (aka 'Hazus') counties, the following parameters were used:

- Thirty-meter resolution Digital Elevation Models (DEM) as the terrain base to develop hydrologic and hydraulic models;
- Streams and rivers with a minimum drainage basin area of 10 square miles all experiencing a base flood at the same time;
- U.S. Geological Survey hydrologic regional regression equations and stream gage data included in Hazus;
- Hazus building inventory with enhanced Level 2 essential facility data from HSIP (2011) summarized to the census block level with a demographic/loss estimate ratio applied to reflect population changes from 2000 – 2010.*

In some cases, 10-meter resolution DEMs were used as a substitute for problem areas in the corresponding 30-meter DEMs. A sensitivity analysis comparing 10-meter DEMs with 30-meter DEMs was run for some counties. While the 10-meter DEM produces slightly more accurate floodplain

boundaries, the slight difference in the impact results did not justify the additional processing time it would have taken to run 10-meter DEMs for all counties.

To develop countywide probabilistic analyses for the DFIRM counties, the following parameters were used:

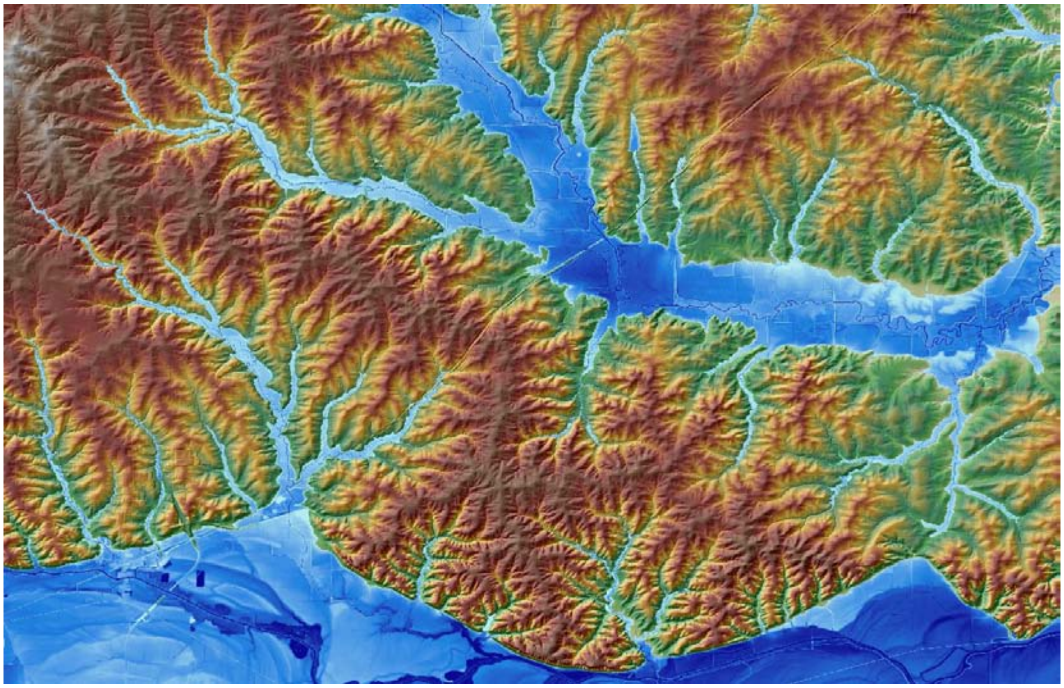
- The resulting depth grids produced from the DFIRM floodplains, generated using the hydrology and hydraulic models and the terrain elevation data (i.e. – LiDAR, DEM) from which the DFIRM was derived;
- Hazus building inventory with enhanced Level 2 essential facility data from HSIP (2011) summarized to the census block level with a demographic/loss estimate ratio applied to reflect population changes from 2000 – 2010.*

** Note: The enhanced Hazus inventory database utilized for Hazus earthquake modeling was comprised of census tracts containing 2010 census demographic data, but this 2010 census information was not yet available at the census block level, which is the data used by the Hazus flood module. To account for these discrepancies a growth ratio was applied to the resulting Hazus loss and vulnerability estimations for the flood analysis.*

When DFIRM boundaries are used to generate a user-defined depth grid, the more accurate, surveyed floodplain boundaries and flood depths are preserved. It should be noted because of the recognition of this increased accuracy, user-generated depth grids were produced wherever DFIRM data was available, both with regards to detailed and approximate (Zone A) flood zones. These data were used in conjunction with available LIDAR data from the Missouri Spatial Data Information Service and the US Army Corps of Engineers. In areas that had DFIRM data where LiDAR was not entirely available, USGS 10 meter digital elevation models were used to supplement these gaps in LiDAR coverage.

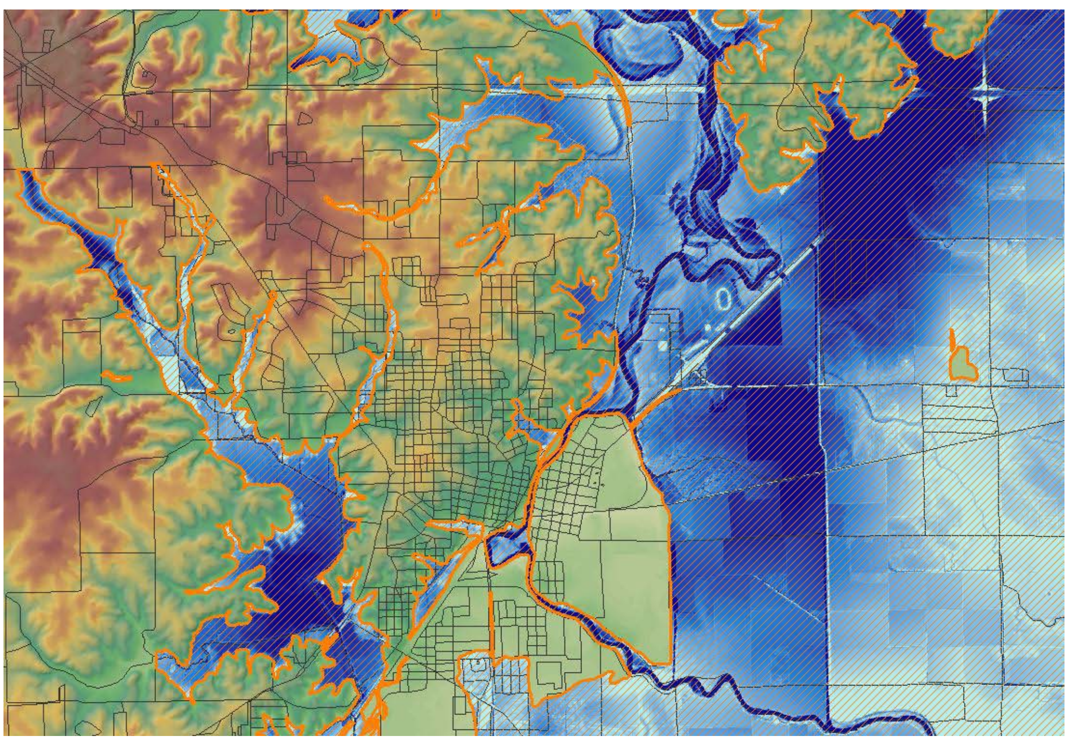
In order to automate the process of generating user-generated (DFIRM) depth grids in areas where they were not previously produced as part of the DFIRM project, ArcGIS Modelbuilder was utilized to create a series of models using DFIRM and elevation data as inputs. The methodologies for approximate and detailed flooding were developed separately to allow for the most accurate results possible. Figure 3.5.1.4 and Figure 3.5.1.5 each show a sample of a depth grid generated by the model and then input into Hazus for flood vulnerability and loss analysis.

Figure 3.5.1.4 - Example of a DFIRM Depth Grid in Approximate Areas — Carroll County



Source: Hazus 2.1 and DFIRM

Figure 3.5.1.5 - Example of a DFIRM Depth Grid in Detailed Areas — Butler County



Source: Hazus 2.1and DFIRM

Black lines make up polygons that indicate census blocks. The smaller the census blocks and the more densely clustered the block polygons, the more likely the area is to be densely developed and populated. The orange line represents the modeled base flood hazard boundary. The blue color indicates flood depth, with deeper blue representing deeper water.

Flood Insurance Claims Analysis

In addition to the Hazus flood runs and local plans, the State analyzed National Flood Insurance Program (NFIP) flood-loss data to determine areas of Missouri with the greatest flood risk. Missouri flood-loss information was obtained from BureauNet which documents losses from 1978 to the present (this analysis is based on the report dated January 31, 2013).

There are several limitations to this data, including:

- Only losses to participating NFIP communities are represented
- Communities joined the NFIP at various times since 1978
- The number of flood insurance policies in effect may not include all structures at risk to flooding,
- Some of the historic loss areas have been mitigated with property buyouts

Despite these limitations, the data depict a pattern of historic flood losses in the State. The greatest losses have been in the counties along the Mississippi River corridor, particularly St. Charles, St. Louis, Jefferson, Lincoln, and St. Genevieve Counties. Counties along the Missouri River corridor also have considerable claims and losses, particularly Clay County. Table 3.5.1a lists the details of the 10 Missouri counties with the greatest historic dollar losses. Figure 3.5.1.6 and Figure 3.5.1.7 show the geographic distribution of flood payouts and claims by county across the entire state. Please note that only communities that participate in the National Flood Insurance Program can have flood insurance losses. Uninsured losses are not depicted in these tables and figures.

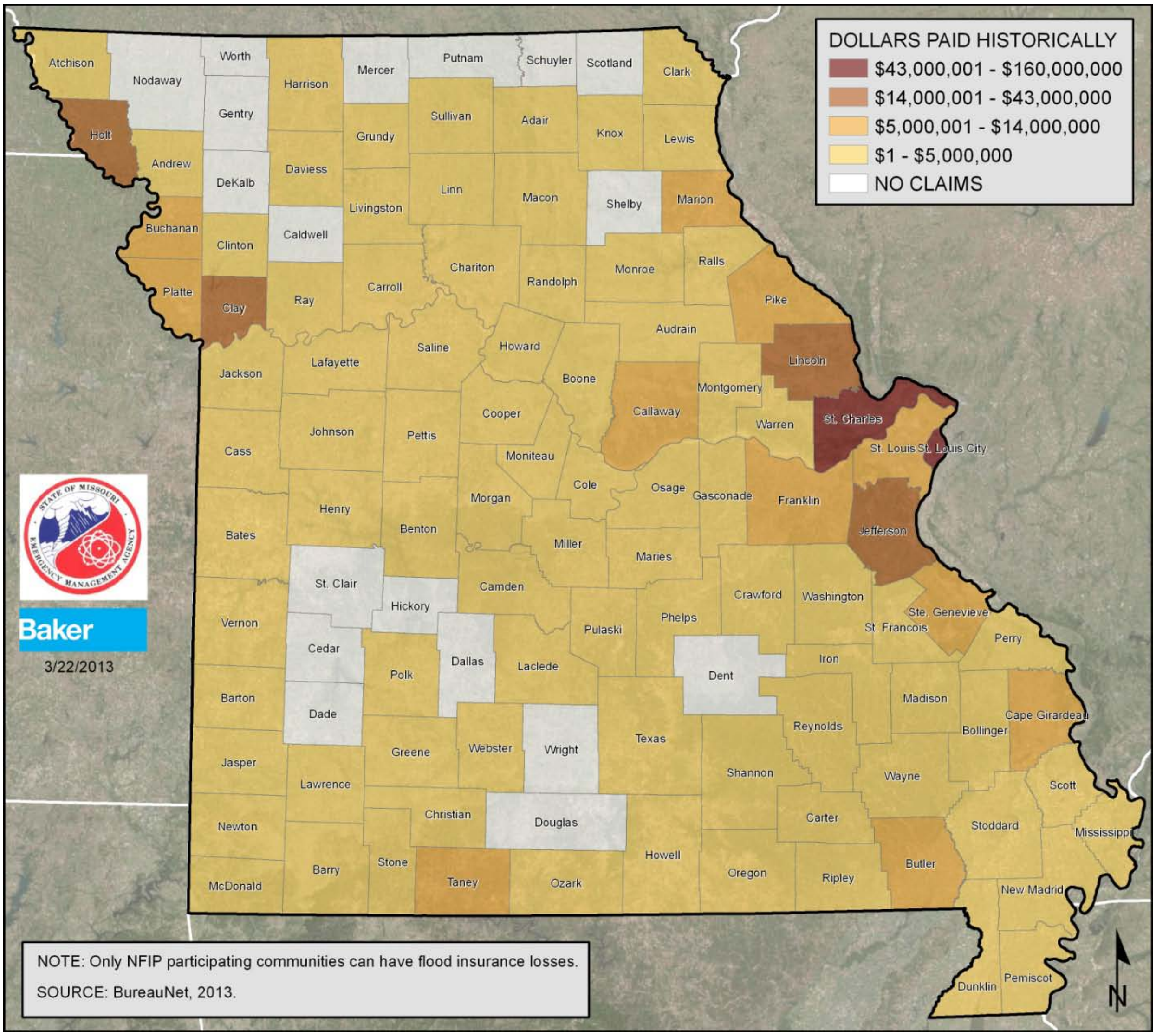
Note that while St. Louis County has the most historical dollars paid, St. Charles County has had more flood claims and has less than half as many policies.

Table 3.5.1a Top 10 Counties for Flood Insurance Dollars Paid (Historical), 1978-2009

County	Dollars Paid (Historical)	Flood Claims	Current Policies	Coverage
St. Louis	$151,415,657	9689	4676	$1,089,509,300
St. Charles	$123,970,794	10362	1949	$385,741,500
Jefferson	$43,417,170	4053	1239	$194,452,100
Clay	$42,425,021	2262	1565	$389,339,600
Holt	$33,031,324	1102	291	$25,478,600
Lincoln	$29,880,866	2093	454	$46,256,100
Franklin	$13,710,493	724	523	$79,947,500
Platte	$13,694,705	371	250	$62,527,400
Buchanan County	$13,362,884	427	467	$80,908,800
Marion	$11,481,529	535	229	$34,485,200
Totals	**476,390,443**	**31,618**	**11,643**	**2,388,646,100**

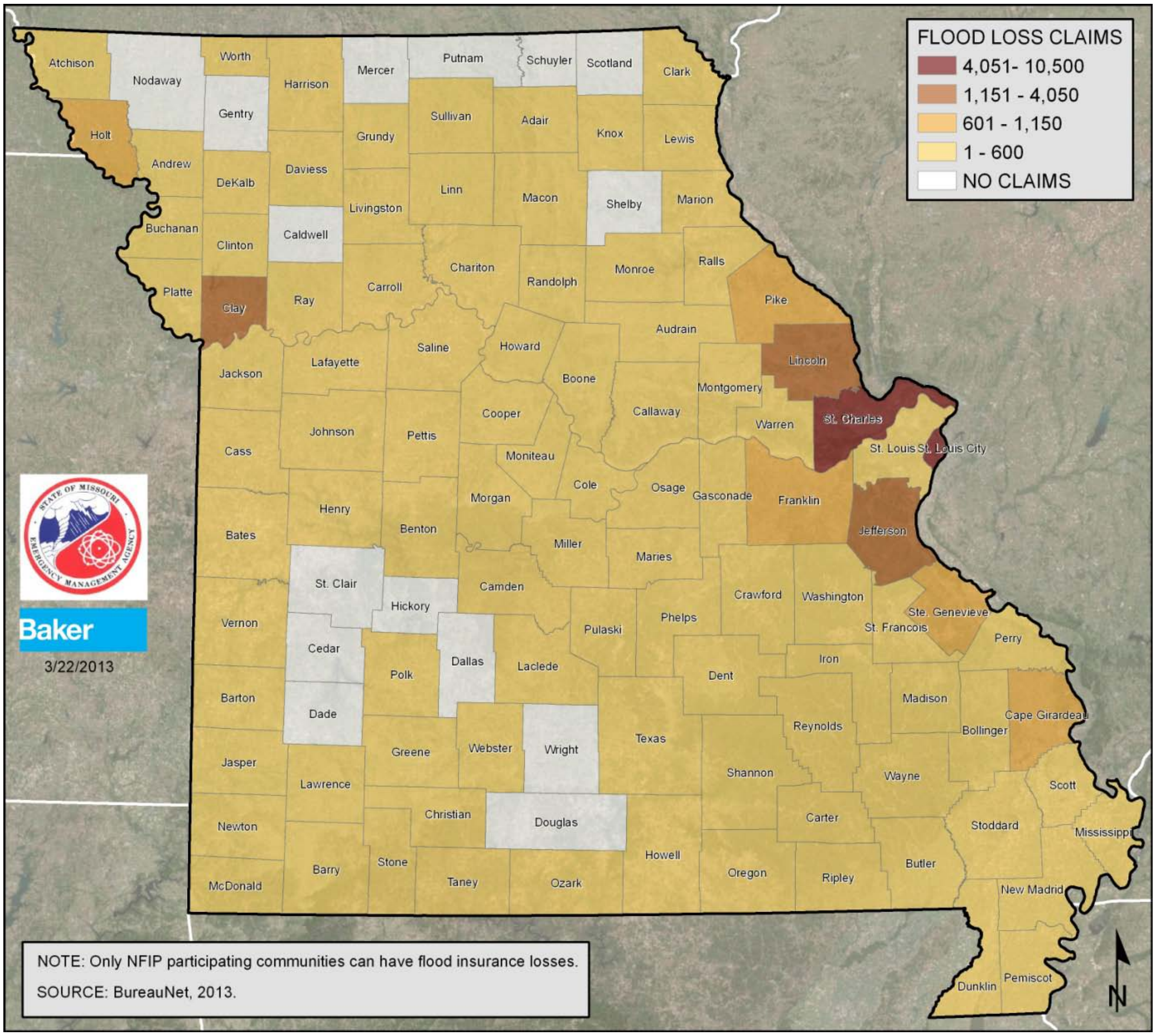
Source: BureauNet, October 31, 2009: Note: Only NFIP participating communities can have flood insurance losses.

Figure 3.5.1.6 - Map of Dollars Paid Historically for Flood Insurance Losses in Missouri by County, 1978-Jan 2013



Note: Only NFIP participating communities can have flood insurance losses.

Figure 3.5.1.7 - Flood Loss Claims in Missouri by County, 1978-Jan 2013



Note: Only NFIP participating communities can have flood insurance losses.

Repetitive Loss and Severe Repetitive Loss Property Analysis

A high priority in Missouri's mitigation strategy is the reduction of losses to repetitive loss structures. These structures strain the National Flood Insurance Fund. They increase the NFIP's annual losses and the need for borrowing and, more importantly, they drain resources needed to prepare for catastrophic events. The NFIP defines a repetitive loss property as "any insurable building for which two or more claims of more than $1,000 were paid by the NFIP within any rolling 10-year period, since 1978. At least two of the claims must be more than 10-days apart."

The Flood Insurance Reform Act of 2004 identified another category of repetitive loss, called severe repetitive loss, and defined it as "a single family property (consisting of one-to-four residences) that is covered under flood insurance by the NFIP and has incurred flood-related damage for which four or more separate claims payments have been paid under flood insurance coverage with the amount of each claim payment exceeding $5,000 and with cumulative amount of such claims payments exceeding

$20,000; or for which at least two separate claims payments have been made with the cumulative amount of such claims exceeding the reported value of the property."

Table 3.5.1b and Figure 3.5.1.8 illustrate the number and location (county) of Missouri's repetitive loss properties. Table 3.5.1c, which shows number of losses by county, also shows loss ratios. Loss ratio is the number of losses divided by the number of properties. A higher loss ratio indicates a lower number of properties with a higher number of losses as a possible indicator of a priority for mitigation. Table 3.5.1b lists the number of severe repetitive loss properties by county.

Table 3.5.1b Missouri's Repetitive Loss Property Summary

County	# of Repetitive Loss Properties	Number of Losses	Total Paid	Loss Ratio	Average Payment
Adair County	1	2	$30,029	2.0	$15,015
Andrew County	18	42	$1,270,096	2.3	$30,240
Atchison County	3	6	$68,851	2.0	$11,475
Audrain County	4	14	$83,120	3.5	$5,937
Barry County	3	14	$693,820	3.5	$49,558
Barton County	1	3	$11,853	3.0	$3,951
Bates County	2	4	$174,974	2.0	$43,744
Bollinger County	12	25	$640,204	2.1	$25,848
Boone County	12	47	$2,573,409	3.9	$54,753
Buchanan County	14	36	$1,085,425	2.5	$20,151
Butler County	43	101	$3,130,692	2.3	$30,997
Callaway County	29	86	$1,799,796	3.0	$20,928
Camden County	2	5	$84,614	2.5	$16,923
Cape Girardeau County	52	155	$2,335,744	3.0	$15,069
Carroll County	13	35	$1,139,829	2.7	$32,567
Carter County	8	18	$244	2.3	$13,547
Cass County	36	120	$2,038,084	3.3	$16,984
Chariton County	4	9	$84,087	2.3	$9,343
Christian County	5	14	$673,958	2.8	$48,140
Clark County	2	4	$183,978	2.0	$45,995
Clay County	182	608	$22,277,727	3.3	$36,641
Cole County	28	114	$2,212,722	4.0	$19,410
Crawford County	7	23	$738,008	3.3	$32,087
Dunklin County	3	6	$16,916	2.0	$2,819
Franklin County	45	132	$1,831,384	2.9	$13,874
Gasconade County	42	185	$3,773,168	4.4	$20,395
Greene County	9	20	$436,248	2.2	$21,812
Holt County	137	344	$11,729,066	2.5	$34,096

County	# of Repetitive Loss Properties	Number of Losses	Total Paid	Loss Ratio	Average Payment
Howard County	3	10	$100,833	3.3	$10,083
Howell County	1	3	$594,131	3	$194,044
Iron County	2	5	$18,662	2.5	$3,732
Jackson County	24	69	$538,058	2.9	$7,798
Jasper County	9	19	$176	2.1	$9,260
Jefferson County	288	1210	$19,966,123	4.2	$16,501
Laclede County	1	4	$152,106	4	$38,026
Lafayette County	2	4	$77,551	2	$19,388
Lewis County	8	23	$413,830	2.9	$17,992
Lincoln County	119	452	$4,816,924	3.8	$10,657
Linn County	4	9	$69,580	2.3	$7,731
Livingston County	1	2	$41,139	2.0	$20,569
Madison County	16	36	$797,081	2.2	$22,141
Maries County	6	15	$544,350	2.5	$36,290
Marion County	21	51	$1,497,057	2.5	$29,354
McDonald County	14	35	$1,552,826	2.5	$44,366
Miller County	2	12	$98,380	6.0	$8,198
Mississippi County	6	14	$105,881	2.3	$7,563
Monroe County	1	3	$11,406	3.0	$3,802
Montgomery County	2	5	$67,185	2.5	$13,437
New Madrid County	8	17	$164,225	2.1	$9,660
Newton County	7	17	$386,790	2.4	$16,870
Osage County	16	44	$743,487	2.6	$16,897
Pemiscot County	7	14	$224,064	2.0	$14,004
Perry County	2	4	$105,299	2.0	$51,235
Pettis County	2	4	$8,848	2.0	$2,212
Phelps County	20	46	$1,601,604	2.3	$34,817
Pike County	66	344	$3,211,283	5.2	$9,335
Platte County	16	43	$1,082,196	2.7	$23,706
Pulaski County	6	13	$201,821	2.2	$16
Ralls County	3	9	$293,319	3.0	$32,591
Ray County	6	17	$238,599	2.8	$14,035
Reynolds County	8	19	$268,187	2.4	$14,115
Ripley County	28	80	$2,025,463	2.9	$25,318
Saline County	1	2	$25,361	2.0	$12,681
Scott County	28	80	$1,393,763	2.9	$17,422
Shannon County	3	7	$84,661	2.3	$12,094

County	# of Repetitive Loss Properties	Number of Losses	Total Paid	Loss Ratio	Average Payment
St. Charles County	485	2399	$45,593,673	4.9	$18,171
St. Francois County	4	25	$624,179	6.2	$24,971
St. Louis County	536	1896	$46,920,453	3.5	$24,747
St. Louis City *	25	77	$2,255,336	3.1	$29,290
Ste. Genevieve	68	252	$2,846,928	3.7	$11,298
Stoddard County	8	18	$306,776	2.3	$17,043
Stone County	4	9	$250,756	2.3	$27,862
Taney County	41	106	$6,417,616	2.6	$60,544
Texas County	1	2	$56,780	2.0	$28,435
Vernon County	1	2	$24,035	2.0	$12,017
Warren County	11	26	$651,165	2.4	$25,044
Washington	1	2	$15,338	2.0	$7,669
Wayne County	8	21	$401,528	2.6	$19,120
Webster County	1	3	$95,704	3.0	$31,901
Totals	**3058**	**10472**	**$189,343,362**	**3.4**	**$23,523**

Figure 3.5.1.8 - Repetitive Flood Loss Properties by County, 1978-2009

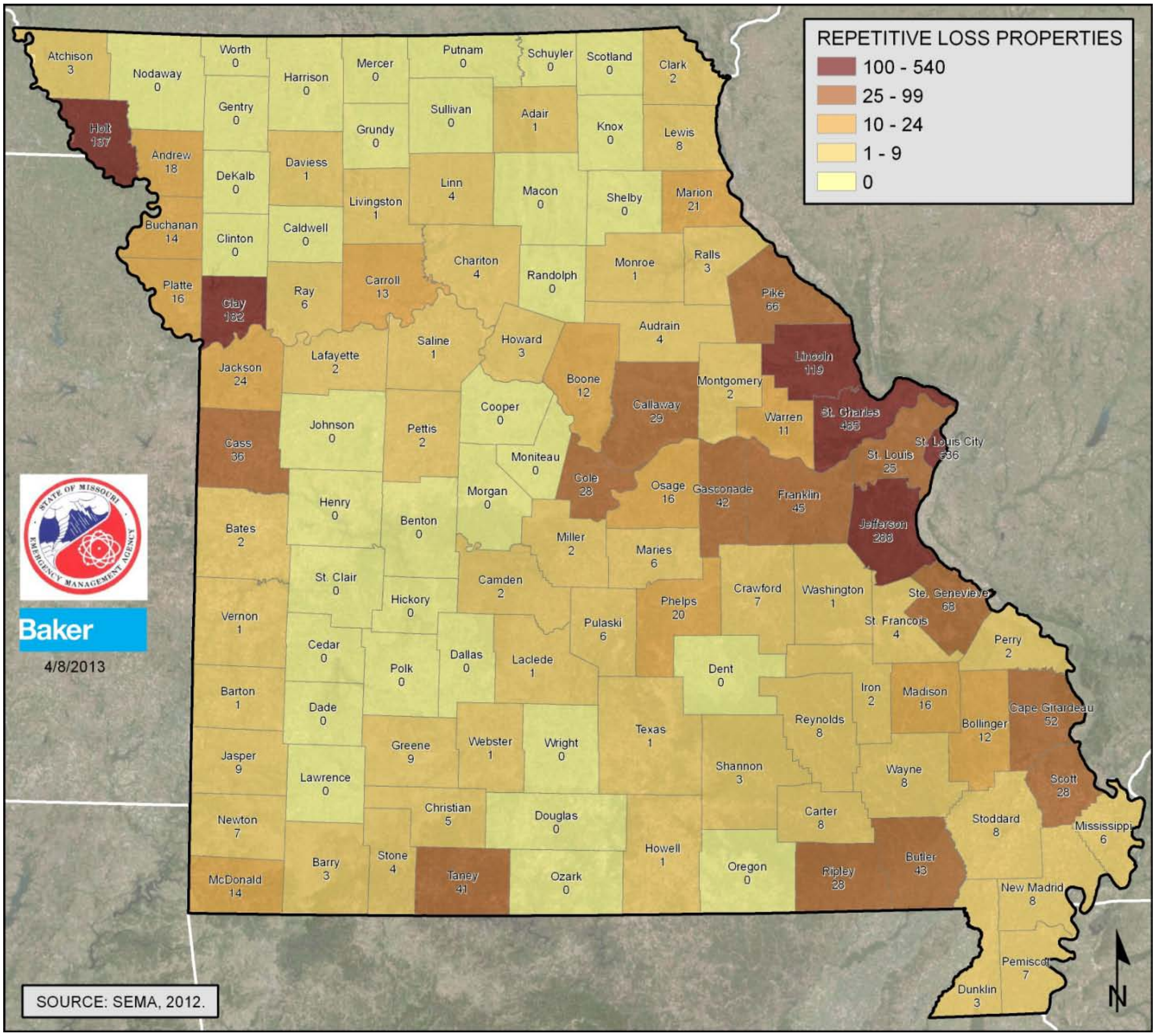


Table 3.5.1c Missouri's Severe Repetitive Loss (SRL) Property Summary

County	Number of SRL Properties
St. Charles	60
Jefferson	54
St. Louis City	21
Holt	10
Clay	8
Pike	6

County	Number of SRL Properties
Gasconade	5
Cass	3
Lincoln	3
Cape Girardeau	2
Franklin	2
Osage	2
Boone	1
Butler	1
Jackson	1
Laclede	1
Newton	1
Phelps	1
Ray	1
Ripley	1
St. Francois	1
St. Genevieve	1
Taney	1
Warren	1
Total	**188**

Overview and Analysis of Potential Loss Estimates to Flooding

The intent of this analysis was to enable the State to estimate where flood losses could occur and the degree of severity using a consistent methodology. The statewide analysis used best available data; that is, DFIRM data where obtainable (79 counties and City of St. Louis) and Hazus-generated floodplain data elsewhere (35 counties). The computer models help quantify risk along known flood-hazard corridors such as along the Mississippi and Missouri Rivers. In addition, flood losses are estimated for certain lesser streams and rivers where the flood hazard may not have been previously studied.

The Hazus analysis provides the number of buildings impacted, estimates of the building repair costs, and the associated loss of building contents and business inventory. Building damage can also cause additional losses to a community as a whole by restricting a building's ability to function properly. Income loss data accounts for losses such as business interruption and rental income losses as well as the resources associated with damage repair and job and housing losses. These losses are calculated by Hazus using a methodology based on the building damage estimates.

Flood damage is directly related to the depth of flooding. For example, a two-foot-deep flood generally results in about 20 percent damage to the structure (which translates to 20 percent of the structure's replacement value). Hazus takes into account flood depth when modeling damage (based on FEMA's depth-damage functions). Hazus reports capture damage by occupancy class (in terms of square footage impacted) by damage percent classes. Occupancy classes in Hazus include agriculture, commercial, education, government, industrial, religion, and residential. Damage percent classes are grouped by 10

percent increments: 1-10 percent, 11-20 percent, etc., up to 50 percent. Buildings that sustain more than 50 percent damage are considered to be substantially damaged.

The displaced population is based on the inundation area. Individuals and households will be displaced from their homes even when the home has suffered little or no damage either because they were evacuated (i.e., a warning was issued) or there was no physical access to the property because of flooded roadways. Displaced people using shelters will most likely be individuals with lower incomes and those who do not have family or friends within the immediate area. Age plays a secondary role in shelter use in that there are some individuals who will go to a public shelter even if they have the financial means to go elsewhere. These will usually be younger, less established families and elderly families (Hazus User's Manual). Hazus does not model flood casualties given that flood-related deaths and injuries typically do not have the same significant impact on the medical infrastructure as those associated with earthquakes.

Hazus impact analyses were completed (on both the DFIRM and the Hazus generated floodplain data) to see which counties ranked the highest on these risk indicators (see the tables and figures that follow). Using GIS, Hazus flood results were mapped to show flood loss potential and how it varies across the State. The primary indicators used to assess flood losses were:

- Direct building losses combined with income losses,
- Loss ratio of the direct building losses compared to overall building inventory (see Table 3.5.1d). The loss ratio of the direct building losses compared to overall building inventory per county gives an indication of the severity of impacts on community sustainability. While a large urban area may have the greatest dollar losses, it may be able to absorb the impact better than a more rural area where a flood could impact a significant amount of the infrastructure in the entire county, and
- Population displaced by the flood and shelter needs.

Table 3.5.1d lists the top ten most severely impacted counties based on building loss, loss ratio, and displaced population indicators. St. Louis, Jackson, Clay, Boone, St. Charles, Jefferson, Greene, Butler, Lincoln and Franklin Counties are present on more than one of these lists and are the most vulnerable to the 100-year flood. Clay and Jackson Counties are split by the Missouri River and are heavily populated with Kansas City metro communities. St. Charles and St. Louis Counties are also split by the Missouri River; they are heavily populated with St. Louis City metro communities. Boone, Carroll, Chariton and Franklin Counties border the Missouri River. Butler, Bollinger, Reynolds, Scott and Wayne counties are subject to extensive flooding in the southern part of the state.

Table 3.5.1d Top Ten Counties at Risk to the 100-year Flood for Building Loss, Loss Ratio, and Displaced Population

Building Loss	Loss Ratio	Displaced Population
Clay	Reynolds	St. Louis
Jackson	Clay	Butler
St. Louis	Douglas	St. Charles
St. Charles	Wayne	Clay
Jefferson	Carroll	Scott
Boone	Butler	Boone
Franklin	Lincoln	Franklin
Greene	Barry	Cass
Butler	Bollinger	Greene
Lincoln	Chariton	Jefferson

Table 3.5.1e and the figures that follow show results of the primary indicators for each of Missouri's 114 Counties and the City of St. Louis.

There are no building counts in Table 3.5.1e because there are a few instances where the Hazus reported damage and loss estimates ($) do not seemingly match the associated counts of buildings impacted. This is caused by rounding errors inherent within the Hazus software. FEMA's Hazus experts have confirmed that this tends to occur when Hazus performs area weighting for relatively minor flood events (where only a few percent of a census block in inundated), in which case Hazus is introducing these conservative losses.

SEMA's Hazus subject matter experts have completed the process of re-reviewing all county Hazus flood loss estimations to ensure that they have been reported accurately in the following tables and figures. Appendix B has been added to the Plan to document this fact.

Some of the data for counties with low flood risks in the following tables may include inconsistencies between the structural loss figures and the substantially damaged building counts. The source of the inconsistencies is in the loss estimation software and is explained more fully in Appendix B. Use of county level data should be accompanied by cautionary language similar to what is included in Appendix B.

Table 3.5.1e Total Direct Building Loss and Income Loss to all Counties and the City of St. Louis

County	Structural Damage	Contents Damage	Inventory Loss	Total Direct Loss	Total Income loss	Total Direct and Income Loss	Calc Loss Ratio
Adair	$3,843,798.30	$4,297,949.35	$178,682.38	$8,320,430.03	$87,214.02	$8,407,644.04	2.70
Andrew	$25,893,962.65	$21,288,913.90	$426,742.91	$47,609,619.45	$258,981.57	$47,868,601.02	5.00
Atchison	$2,210,205.29	$3,117,181.96	$203,409.33	$5,530,796.58	$55,475.27	$5,586,271.85	3.00
Audrain	$13,151,093.57	$19,345,477.86	$561,869.07	$33,058,440.49	$236,992.23	$33,295,432.72	1.80
Barry	$63,903,993.97	$89,643,524.23	$5,614,298.97	$159,161,817.17	$1,460,094.53	$160,621,911.70	6.00
Barton	$14,602,338.89	$19,880,185.47	$685,319.03	$35,167,843.39	$213,605.93	$35,381,449.33	3.00
Bates	$11,884,032.43	$8,924,285.89	$549,769.59	$21,358,087.91	$5,118.90	$21,363,206.81	4.00
Benton	$33,080,683.59	$28,698,247.26	$844,098.72	$62,623,029.57	$521,322.47	$63,144,352.04	5.20
Bollinger	$14,688,834.98	$19,443,281.57	$345,329.45	$34,477,446.01	$200,414.42	$34,677,860.42	6.00
Boone	$197,173,108.25	$288,692,780.21	$3,770,580.61	$489,636,469.07	$4,317,059.61	$493,953,528.68	3.00
Buchanan	$21,265,612.98	$54,095,035.12	$7,296,846.63	$82,657,494.73	$289,574.30	$82,947,069.03	4.00
Butler	$98,419,812.37	$124,378,734.24	$6,171,919.54	$228,970,466.15	$2,282,793.45	$231,253,259.60	6.30
Caldwell	$2,415,628.94	$2,382,005.57	$105,073.03	$4,902,707.55	$3,152.19	$4,905,859.74	1.50
Callaway	$39,761,343.18	$59,543,598.29	$2,232,585.88	$101,537,527.35	$844,967.96	$102,382,495.31	2.30
Camden	$62,149,073.33	$82,010,315.73	$4,465,602.55	$148,624,991.61	$964,380.12	$149,589,371.73	1.60
Cape Girardeau	$80,972,942.78	$119,944,837.09	$7,384,905.97	$208,302,685.84	$1,280,408.42	$209,583,094.26	3.80
Carroll	$20,830,734.08	$29,328,682.55	$3,466,815.75	$53,626,232.38	$111,220.22	$53,737,452.60	6.40
Carter	$10,545,362.73	$10,060,276.05	$43,235.99	$20,648,874.77	$554,686.08	$21,203,560.85	6.00
Cass	$87,234,525.00	$72,905,452.20	$1,786,856.40	$161,926,833.60	$700,320.60	$162,627,154.20	2.70
Cedar	$12,115,764.95	$13,909,712.66	$416,415.79	$26,441,893.40	$163,919.17	$26,605,812.57	4.00
Chariton	$13,246,152.17	$10,110,990.28	$173,347.24	$23,530,489.69	$178,007.11	$23,708,496.80	6.00
Christian	$38,448,601.71	$47,870,377.23	$1,699,826.91	$88,018,805.86	$446,347.17	$88,465,153.03	2.00

County	Structural Damage	Contents Damage	Inventory Loss	Total Direct Loss	Total Income loss	Total Direct and Income Loss	Calc Loss Ratio
Clark	$7,316,127.29	$10,182,894.01	$284,943.91	$17,783,965.21	$221,409.12	$18,005,374.33	4.60
Clay	$750,802,961.93	$1,386,971,026.96	$102,207,855.09	$2,239,981,843.98	$11,297,860.28	$2,251,279,704.26	11.50
Clinton	$9,261,614.52	$8,429,883.50	$146,454.61	$17,837,952.63	$42,624.85	$17,880,577.48	1.00
Cole	$88,997,018.47	$94,867,199.01	$2,532,276.26	$186,396,493.75	$1,526,564.53	$187,923,058.28	4.00
Cooper	$19,152,542.95	$17,705,771.93	$640,426.03	$37,498,740.91	$202,907.26	$37,701,648.17	4.00
Crawford	$25,282,968.60	$33,544,930.71	$967,090.34	$59,794,989.65	$834,968.25	$60,629,957.90	3.00
Dade	$3,410,693.42	$2,341,120.66	$75,616.31	$5,827,430.39	$17,909.13	$5,845,339.52	2.20
Dallas	$8,149,073.43	$5,650,895.54	$112,482.28	$13,912,451.25	$117,838.58	$14,030,289.83	2.00
Daviess	$8,645,508.23	$14,710,409.06	$2,842,560.63	$26,198,477.92	$50,497.01	$26,248,974.93	3.60
DeKalb	$4,813,517.29	$5,195,930.67	$259,018.37	$10,268,466.33	$27,791.67	$10,296,258.00	2.70
Dent	$10,804,076.91	$12,725,547.53	$180,400.08	$23,710,024.52	$62,930.26	$23,772,954.78	3.80
Douglas	$17,690,680.22	$23,681,352.19	$1,478,842.56	$42,850,874.96	$281,335.68	$43,132,210.64	9.10
Dunklin	$1,229,739.95	$1,904,362.18	$96,374.60	$3,230,476.73	$16,383.68	$3,246,860.41	0.80
Franklin	$205,481,079.49	$202,247,210.08	$9,545,811.25	$417,274,100.82	$1,449,777.52	$418,723,878.35	4.60
Gasconade	$30,927,050.71	$27,889,182.24	$706,319.32	$59,522,552.27	$565,254.14	$60,087,806.41	5.00
Gentry	$3,566,887.63	$4,214,073.46	$167,934.41	$7,948,865.50	$38,300.83	$7,987,196.33	2.80
Greene	$98,824,144.76	$138,488,939.14	$7,513,870.73	$244,826,954.64	$1,242,878.18	$246,069,832.81	2.00
Grundy	$1,626,887.85	$2,101,970.57	$62,950.92	$3,791,809.34	$20,655.77	$3,812,465.11	1.70
Harrison	$6,531,019.32	$9,176,623.62	$285,406.49	$15,993,052.43	$183,188.36	$16,176,240.79	3.10
Henry	$33,412,556.26	$33,383,193.71	$823,163.89	$67,618,913.85	$498,150.84	$68,117,064.69	3.60
Hickory	$9,909,133.56	$8,376,782.21	$50,611.74	$18,336,527.52	$82,917.11	$18,419,444.63	5.00
Holt	$1,668,921.70	$2,388,473.18	$275,417.68	$4,332,812.56	$8,207.81	$4,341,020.37	2.10
Howard	$5,998,251.47	$7,496,822.56	$330,260.87	$13,825,334.90	$61,490.01	$13,886,824.91	2.20
Howell	$23,533,436.03	$49,504,732.50	$3,402,372.20	$76,440,540.74	$632,520.09	$77,073,060.82	2.10

County	Structural Damage	Contents Damage	Inventory Loss	Total Direct Loss	Total Income loss	Total Direct and Income Loss	Calc Loss Ratio
Iron	$22,364,273.35	$22,270,844.54	$457,204.82	$45,092,322.71	$455,216.98	$45,547,539.68	5.70
Jackson	$726,945,824.79	$1,149,784,783.74	$66,531,805.72	$1,943,262,414.25	$16,461,574.62	$1,959,723,990.86	5.60
Jasper	$70,711,197.41	$107,283,604.05	$2,402,940.05	$180,397,741.51	$2,744,918.75	$183,142,660.26	3.10
Jefferson	$353,612,419.73	$347,763,817.69	$14,461,957.63	$715,838,195.04	$3,544,272.71	$719,382,467.76	4.20
Johnson	$29,476,654.03	$28,637,453.27	$1,045,186.39	$59,159,293.69	$189,637.57	$59,348,931.27	2.00
Knox	$1,049,563.86	$1,084,612.47	$31,259.57	$2,165,435.91	$16,103.42	$2,181,539.33	1.60
Laclede	$21,772,782.30	$29,939,900.53	$1,871,927.57	$53,584,610.40	$542,651.12	$54,127,261.53	2.10
Lafayette	$10,803,813.26	$11,517,989.38	$454,844.08	$22,776,646.72	$65,846.03	$22,842,492.75	1.20
Lawrence	$16,136,641.75	$27,828,683.45	$1,376,179.87	$45,341,505.06	$313,865.58	$45,655,370.64	2.10
Lewis	$10,563,237.66	$7,923,401.28	$189,741.28	$18,676,380.22	$42,813.42	$18,719,193.63	5.40
Lincoln	$116,090,040.06	$103,608,822.03	$3,386,544.40	$223,085,406.48	$1,608,912.28	$224,694,318.77	6.00
Linn	$6,976,149.41	$8,474,550.97	$428,644.90	$15,879,345.28	$126,181.18	$16,005,526.47	3.10
Livingston	$12,437,396.62	$22,185,034.00	$2,890,160.39	$37,512,591.02	$140,907.06	$37,653,498.08	4.50
Macon	$13,437,797.36	$11,826,091.23	$404,901.66	$25,668,790.26	$99,744.07	$25,768,534.32	2.90
Madison	$25,081,970.34	$35,400,699.15	$1,900,055.08	$62,382,724.58	$548,052.97	$62,930,777.54	5.20
Maries	$3,849,948.89	$3,064,497.47	$88,646.75	$7,003,093.11	$4,123.10	$7,007,216.22	2.20
Marion	$26,666,903.10	$29,603,217.23	$1,723,622.55	$57,993,742.88	$144,661.18	$58,138,404.05	3.80
McDonald	$20,217,986.72	$19,498,273.23	$449,288.59	$40,165,548.54	$647,316.27	$40,812,864.81	3.80
Mercer	$1,133,384.35	$1,668,341.76	$124,924.14	$2,926,650.25	$6,044.72	$2,932,694.97	2.10
Miller	$19,960,415.12	$16,373,064.25	$411,663.22	$36,745,142.59	$436,867.09	$37,182,009.68	2.70
Mississippi	$458,477.16	$624,457.50	$29,017.54	$1,111,952.20	$11,607.02	$1,123,559.22	0.40
Moniteau	$9,252,413.17	$8,240,858.10	$332,623.73	$17,825,894.99	$73,682.47	$17,899,577.46	2.50
Monroe	$10,040,060.14	$7,091,178.18	$124,373.32	$17,255,611.64	$34,178.93	$17,289,790.57	3.50
Montgomery	$5,789,916.94	$7,150,829.27	$481,150.96	$13,421,897.17	$178,166.78	$13,600,063.94	1.40

County	Structural Damage	Contents Damage	Inventory Loss	Total Direct Loss	Total Income loss	Total Direct and Income Loss	Calc Loss Ratio
Morgan	$13,017,009.17	$12,340,704.08	$559,149.88	$25,916,863.12	$155,496.92	$26,072,360.04	1.30
New Madrid	$1,946,407.89	$4,932,243.67	$325,361.08	$7,204,012.65	$45,109.06	$7,249,121.71	1.10
Newton	$37,693,061.02	$60,187,449.58	$2,997,558.90	$100,878,069.50	$940,670.42	$101,818,739.91	2.30
Nodaway	$3,823,407.58	$8,801,373.71	$715,444.47	$13,340,225.76	$117,566.01	$13,457,791.78	2.00
Oregon	$15,644,067.29	$19,694,988.69	$367,118.04	$35,706,174.01	$793,143.27	$36,499,317.29	5.10
Osage	$22,096,801.79	$13,837,705.18	$333,557.27	$36,268,064.23	$51,400.63	$36,319,464.86	3.70
Ozark	$17,174,718.61	$15,397,637.08	$1,006,741.14	$33,579,096.84	$352,563.19	$33,931,660.03	4.90
Pemiscot	$863,859.38	$1,109,242.88	$54,732.38	$2,027,834.64	$6,385.44	$2,034,220.08	0.80
Perry	$13,764,751.60	$12,777,071.03	$573,356.94	$27,115,179.57	$58,591.22	$27,173,770.79	2.00
Pettis	$10,215,522.22	$9,405,093.69	$330,897.86	$19,951,513.77	$40,141.71	$19,991,655.48	3.10
Phelps	$30,148,220.56	$43,059,491.68	$462,615.14	$73,670,327.38	$687,119.55	$74,357,446.93	2.20
Pike	$14,041,123.43	$16,118,636.59	$1,082,647.70	$31,242,407.72	$197,762.30	$31,440,170.02	2.50
Platte	$27,129,198.89	$28,806,898.90	$994,414.20	$56,930,511.99	$217,789.87	$57,148,301.87	3.20
Polk	$17,329,354.62	$21,488,353.59	$490,311.94	$39,308,020.15	$606,833.14	$39,914,853.29	1.80
Pulaski	$37,629,025.00	$43,977,986.49	$683,148.26	$82,290,159.75	$450,776.27	$82,740,936.01	3.80
Putnam	$1,247,848.17	$1,025,733.10	$66,729.85	$2,340,311.12	$16,205.82	$2,356,516.94	1.80
Ralls	$10,791,215.35	$7,354,334.20	$109,845.00	$18,255,394.56	$17,955.43	$18,273,349.99	3.00
Randolph	$2,749,603.20	$2,515,529.17	$50,085.71	$5,315,218.08	$97,104.95	$5,412,323.03	2.40
Ray	$21,679,766.16	$17,591,616.17	$401,272.29	$39,672,654.62	$315,788.22	$39,988,442.84	2.90
Reynolds	$50,670,971.45	$96,561,945.88	$1,707,785.32	$148,940,702.65	$991,036.03	$149,931,738.68	14.70
Ripley	$11,010,504.11	$12,461,314.68	$456,118.14	$23,927,936.93	$444,636.91	$24,372,573.84	5.30
Saline	$5,842,222.54	$4,679,669.35	$41,239.22	$10,563,131.11	$38,293.56	$10,601,424.67	3.70
Schuyler	$555,734.53	$286,899.28	$1,062.59	$843,696.40	$0.00	$843,696.40	1.60
Scotland	$1,469,519.57	$1,486,041.94	$48,595.22	$3,004,156.73	$5,831.43	$3,009,988.16	3.00

County	Structural Damage	Contents Damage	Inventory Loss	Total Direct Loss	Total Income loss	Total Direct and Income Loss	Calc Loss Ratio
Scott	$74,347,675.82	$109,645,878.58	$7,090,472.91	$191,084,027.31	$1,911,024.49	$192,995,051.80	5.90
Shannon	$6,286,876.26	$7,718,892.60	$88,233.30	$14,094,002.16	$88,233.30	$14,182,235.46	4.40
Shelby	$2,940,447.27	$6,702,007.65	$568,967.64	$10,211,422.56	$8,436.09	$10,219,858.66	4.30
St. Charles	$423,383,753.53	$533,879,473.55	$15,240,523.95	$972,503,751.02	$6,855,545.82	$979,359,296.84	5.30
St. Clair	$7,797,677.17	$5,991,492.95	$41,649.92	$13,830,820.04	$233,645.88	$14,064,465.91	4.60
Ste. Genevieve	$31,900,546.35	$33,332,243.53	$1,582,132.83	$66,814,922.71	$244,585.86	$67,059,508.58	3.70
St. Francois	$49,124,005.41	$53,527,142.93	$1,744,838.52	$104,395,986.86	$675,421.36	$105,071,408.22	2.90
St. Louis	$506,392,178.49	$708,125,680.60	$36,400,586.72	$1,250,918,445.80	$6,878,464.00	$1,257,796,909.80	5.00
St. Louis City	$26,733,059.27	$31,203,559.39	$1,118,136.06	$59,054,754.73	$379,185.08	$59,433,939.81	3.20
Stoddard	$3,155,767.68	$3,764,156.98	$305,201.92	$7,225,126.58	$23,167.14	$7,248,293.73	1.80
Stone	$70,013,337.15	$55,487,715.89	$1,242,773.82	$126,743,826.85	$666,333.52	$127,410,160.37	5.80
Sullivan	$3,057,990.30	$4,253,099.04	$521,755.64	$7,832,844.99	$6,510.32	$7,839,355.31	3.20
Taney	$96,472,273.43	$93,416,437.45	$2,049,804.80	$191,938,515.68	$1,078,913.13	$193,017,428.81	5.90
Texas	$8,874,355.17	$7,272,245.19	$236,302.74	$16,382,903.10	$21.48	$16,382,924.58	3.20
Vernon	$3,345,614.77	$1,918,965.86	$7,491.78	$5,272,072.41	$1,070.25	$5,273,142.66	3.00
Warren	$16,663,342.14	$21,776,756.94	$1,568,361.35	$40,008,460.43	$96,779.69	$40,105,240.12	1.10
Washington	$6,745,844.76	$8,942,291.81	$269,833.79	$15,957,970.36	$302,213.85	$16,260,184.20	1.30
Wayne	$56,844,490.76	$61,644,501.85	$2,882,861.98	$121,371,854.59	$984,068.56	$122,355,923.15	9.00
Webster	$8,754,257.40	$6,651,696.31	$184,251.05	$15,590,204.77	$65,304.17	$15,655,508.94	1.20
Worth	$1,598,628.88	$948,787.15	$23,696.89	$2,571,112.93	$0.00	$2,571,112.93	4.10
Wright	$7,971,980.62	$10,291,902.42	$631,848.62	$18,895,731.66	$75,444.61	$18,971,176.27	5.70

*# Bldgs Risk = # of buildings at risk in the Hazus/DFIRM floodplain.

Figure 3.5.1.9 - Hazus Countywide Base-Flood Scenarios: Building and Income Loss

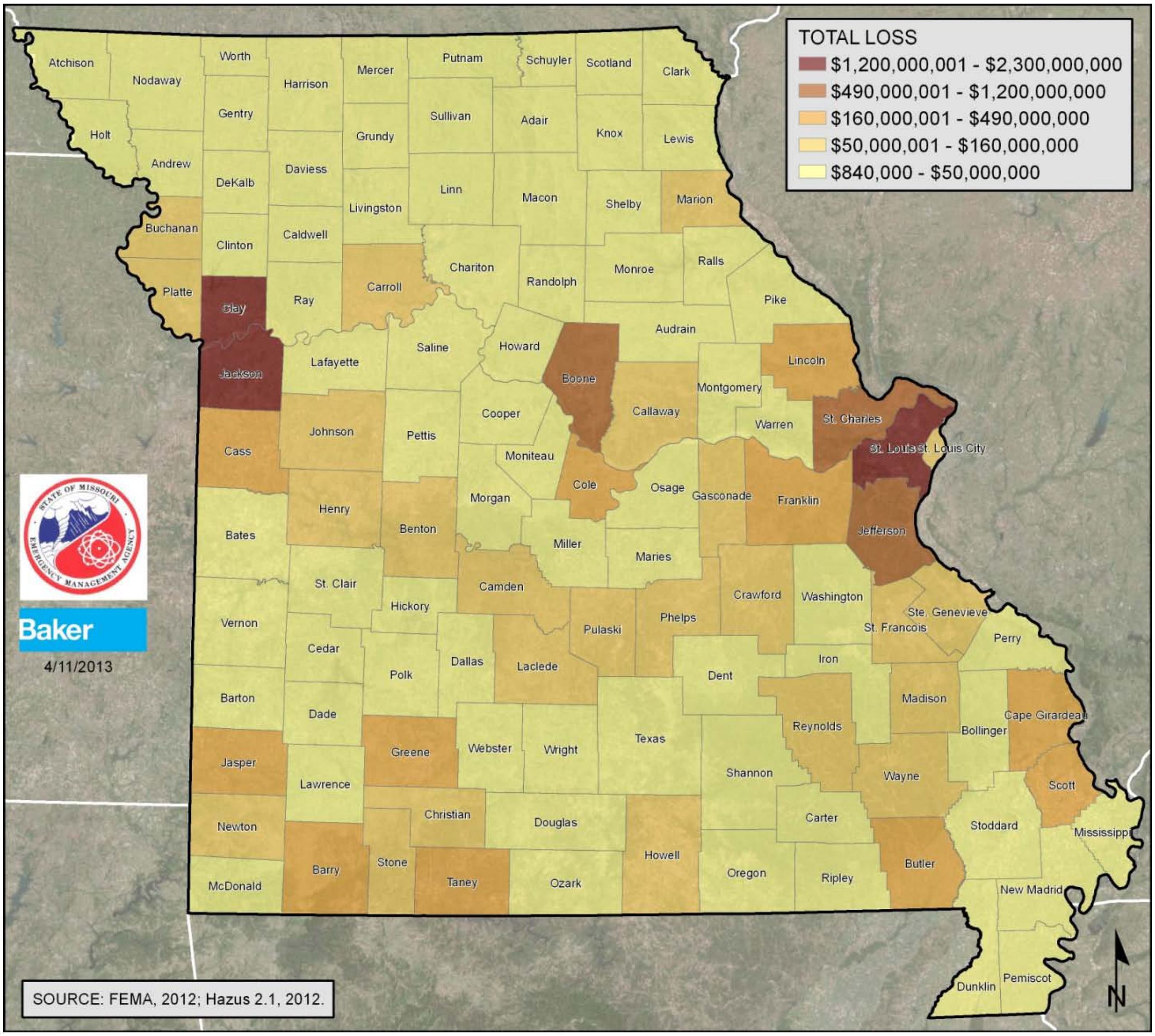


Figure 3.5.1.10 - Hazus Countywide Base-Flood Scenarios: Building Loss Ratio

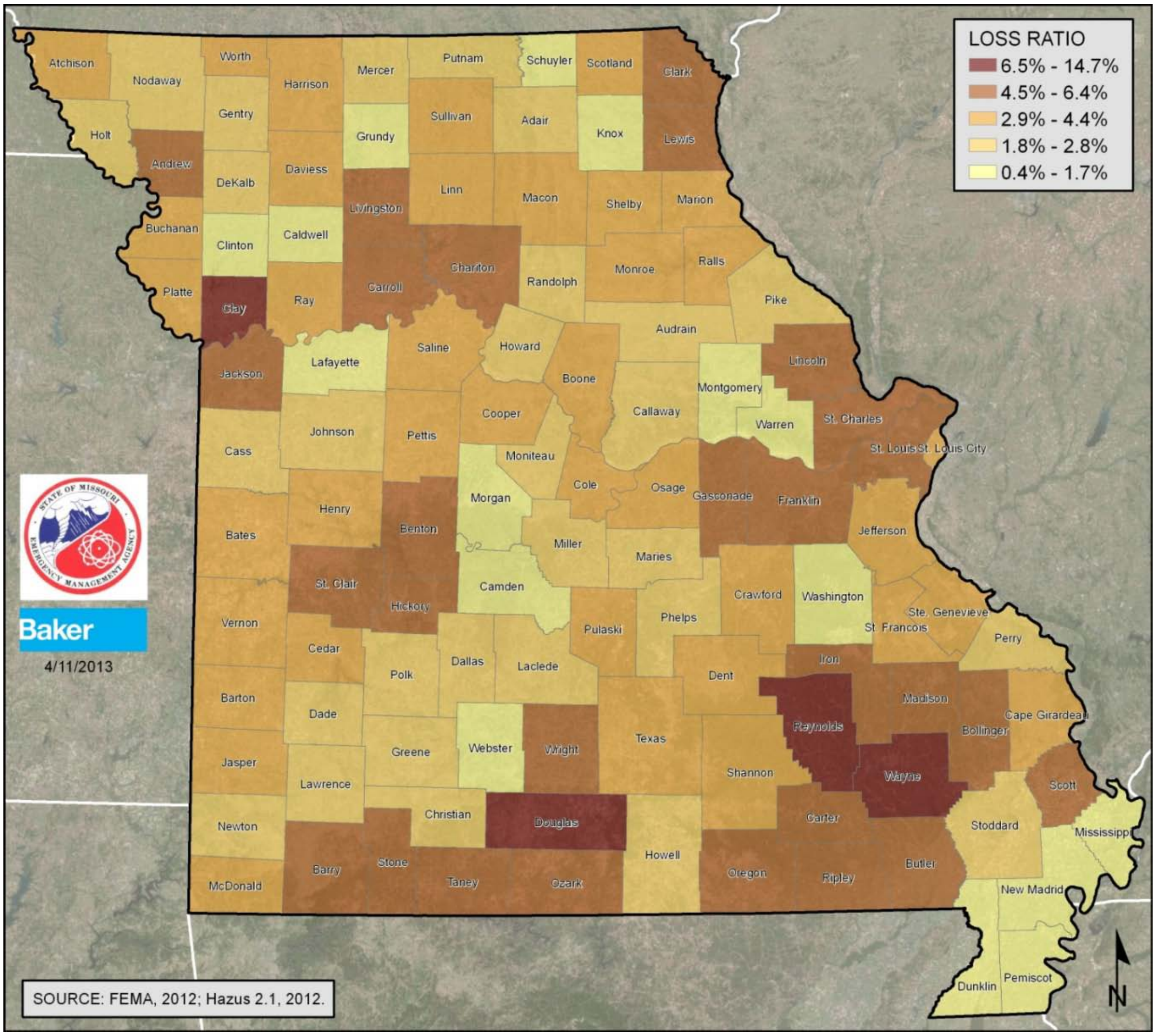


Table 3.5.1f Estimated Displaced Households and Shelter Needs for all Counties and the City of St. Louis

County	Displaced Households	Displaced Population Requiring Shelter
Adair	299	16
Andrew	1131	273
Atchison	201	13
Audrain	1362	530
Barry	2477	600
Barton	1314	391

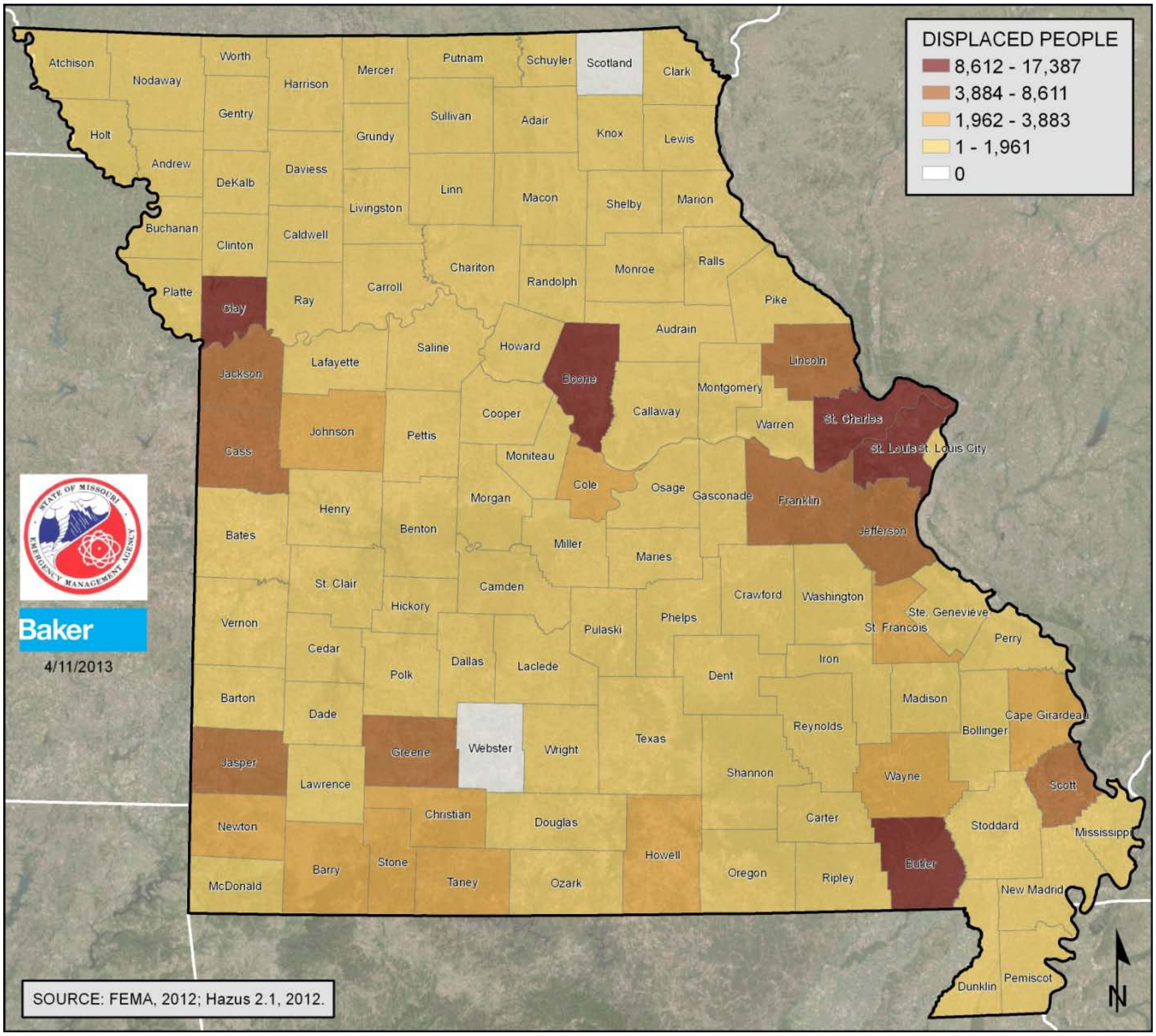
County	Displaced Households	Displaced Population Requiring Shelter
Bates	1068	133
Benton	1101	325
Bollinger	912	344
Boone	10417	6685
Buchanan	1091	538
Butler	10337	6270
Caldwell	340	6
Callaway	1931	312
Camden	938	607
Cape Girardeau	3675	1348
Carroll	829	93
Carter	341	105
Cass	5697	1965
Cedar	660	101
Chariton	992	141
Christian	2430	509
Clark	552	77
Clay	11656	8613
Clinton	624	57
Cole	3883	2373
Cooper	962	175
Crawford	1058	148
Dade	254	6
Dallas	761	56
Daviess	380	16
DeKalb	524	54
Dent	475	104
Douglas	225	3
Dunklin	759	106

County	Displaced Households	Displaced Population Requiring Shelter
Franklin	8611	4496
Gasconade	1125	197
Gentry	148	101
Greene	6466	2819
Grundy	144	17
Harrison	168	72
Henry	1614	428
Hickory	339	79
Holt	246	50
Howard	601	167
Howell	2405	989
Iron	1358	385
Jackson	4716	9148
Jasper	5533	2590
Jefferson	5656	11073
Johnson	2418	635
Knox	139	19
Laclede	1228	248
Lafayette	894	85
Lawrence	1710	393
Lewis	702	204
Lincoln	5078	1701
Linn	732	154
Livingston	562	169
Macon	1080	110
Madison	1211	358
Maries	182	8
Marion	1510	645
McDonald	1703	538

County	Displaced Households	Displaced Population Requiring Shelter
Mercer	48	0
Miller	940	103
Mississippi	331	89
Moniteau	561	25
Monroe	666	31
Montgomery	498	31
Morgan	914	94
New Madrid	799	246
Newton	3737	1571
Nodaway	563	28
Oregon	655	108
Osage	1095	220
Ozark	526	21
Pemiscot	428	103
Perry	819	113
Pettis	678	149
Phelps	619	375
Pike	979	142
Platte	1266	730
Polk	1462	245
Pulaski	1642	668
Putnam	104	0
Ralls	647	135
Randolph	228	6
Ray	1961	678
Reynolds	761	245
Ripley	541	115
Saline	337	109
Schuyler	63	0

County	Displaced Households	Displaced Population Requiring Shelter
Scotland	0	0
Scott	8323	5886
Shannon	266	68
Shelby	91	1
St. Charles	13787	9825
St. Clair	379	28
Ste. Genevieve	1307	399
St. Francois	2757	891
St. Louis	17387	14882
St. Louis City*	622	1547
Stoddard	840	138
Stone	2193	687
Sullivan	194	9
Taney	3475	1866
Texas	339	15
Vernon	423	130
Warren	1152	220
Washington	848	138
Wayne	2431	1015
Webster	0	0
Worth	118	3
Wright	222	10

Figure 3.5.1.11 - Hazus Countywide Base-Flood Scenarios: Displaced People



Data Limitation Note

Impacts estimated in counties where DFIRM flood data was integrated typically increased the losses when compared to the Hazus-generated flood data. There are more stream reaches (due to the smaller drainage area modeled) and therefore more buildings and population inventory are affected and included in loss estimates. In addition a more detailed digital elevation model was used to create the DFIRM, thus the depth grid is more precise. The DFIRM/Hazus floodplain source difference makes comparisons between counties inconsistent (not ‘apples to apples’). The State anticipates integrating even more accurate and reliable DFIRM data in future updates to this plan. For these reasons, it was decided that DFIRM flood data be integrated where possible in the plan update. As it stands now, almost 70% of the state has been modeled using DFIRM floodplains. In the future, nearly all of the State will be mapped with DFIRM boundaries and can be used in future updates to this plan.

The damaged building counts generated by Hazus are susceptible to rounding errors and are likely the weakest output of the model due to the use of census blocks for analysis. Hazus reports include this disclaimer: "Unlike the earthquake and hurricane models, the flood model performs its analysis at the census block level. This means that the analysis starts with a small number of buildings within each census block and applies a series of distributions necessary for analyzing the potential damage. The application of these distributions and the small number of buildings make the flood model more sensitive to rounding errors that introduces uncertainty into the building count results. Please use these results with suitable caution." The counts of buildings at risk collected from the local hazard mitigation plans could potentially provide a more realistic estimate of the actual numbers of buildings in the base-flood hazard areas.

Some of the data for counties with low flood risks in the following tables may include inconsistencies between the structural loss figures and the substantially damaged building counts. The source of the inconsistencies is in the loss estimation software and is explained more fully in Appendix B. Use of county level data should be accompanied by cautionary language similar to what is included in Appendix B.

Hazus analyzes loss estimates for critical infrastructure and facilities as well, including vehicle losses, utility system losses, essential facility impacts, transportation impacts, as well as agricultural losses. Hazus also provides the results in more detail, and some results, spatially. Project files for each county are available for use by local governments from SEMA.

Levees may not be detected on the computer terrain models. Thus, some communities that may be protected from 100-year floods from levees may be modeled by Hazus as inundated and the risk may be overestimated. Pemiscot County is one example where levee protection is not recognized by Hazus. These results, for those counties with levee protection, should be considered as the "worst-case scenario" and may represent losses that could result from a levee breach.

Lastly, it should be noted that the loss estimates presented in Table 3.106 have been adjusted to maintain consistency between the other hazard (earthquakes) modeled using FEMAs Hazus software. Results derived from earthquake runs in Hazus are aggregated to the census tract level, data which has been updated by FEMA to reflect the 2010 census effort. Results derived from flood hazard runs however, are aggregated to the census block level, which contains demographic information from the 2000 census effort.

At the time of this analysis, the demographic data required by Hazus was not available at the census block level therefore a discrepancy between the two sources (blocks and tracts) was present. In order to maintain some level of consistency as well as generate the most accurate loss estimates possible, a ratio was applied to all of the flood loss estimates based on the change in population (from 2000 to 2010) identified in each "at risk" census tract.

Agricultural Losses

Hazus also has the ability to model flood losses to agriculture, in particular crop losses. To model crop losses, Hazus uses the National Resources Inventory (NRI) data as the default agriculture inventory. The NRI provides crop type and units data captured approximately every five years. The southeast Missouri Bootheel region is where the State's prime agricultural lands are located, in the lowlands of the Mississippi River floodplain. The following counties were analyzed for crop losses from flooding,

identified by the Missouri Department of Agriculture: Bollinger, Butler, Cape Girardeau, Stoddard, Scott, New Madrid, Mississippi, Dunklin, and Pemiscot. A hypothetical flood date of September 1 was used as the target date because it has the potential to harm not only the crop in the field but also the next growing season. For comparative purposes, the State compared the Hazus generated potential losses against paid crop insurance claims data received from USDA Risk Management Agency as a result of flooding in these counties in 2008. This comparison shows that the Hazus estimates were much higher than claims paid. Please note that not all farmers carry crop insurance and not all that do file a claim. For the period from 1998 to 2008, USDA's Risk Management Agency paid crop insurance claims as a result of excess moisture/rain was $318,842,614 the paid claims for flooding during this period totaled $101,884,569. During this time period, excess moisture/rain and flooding followed drought as the number 2 and number 3 causes of loss for crop insurance claims made.

Table 3.5.1g summarizes potential impacts to agriculture from this hypothetical flood in the Bootheel region. A flood in late May or early June could also prove devastating since crops would have been recently planted. One limitation to the data used in this analysis is the absence of cotton in the Hazus default agriculture data. Cotton is a major commodity in the Bootheel region. Table 3.5.1h shows the insured crop losses in these same counties over the 4-year period of 2009-2012. In all nine cases, the crop losses attributed to excess moisture exceeded those losses due to flood events.

Table 3.5.1g Hazus Agricultural Losses with 2008 USDA Crop Insurance Claims

	Day 3	Day 7	Day 14
Bollinger			
CORN	$6,471,531	$6,471,531	$6,471,531
SOYBEANS	$4,437,877	$5,917,169	$5,917,169
WHEAT	$639,936	$639,936	$639,936
Study Case Total	$11,549,344	$13,028,637	$13,028,637
Butler			
CORN	$41,003,025	$41,003,025	$41,003,025
SOYBEANS	$31,149,143	$41,532,190	$41,532,190
WHEAT	$24,175,224	$24,175,224	$24,175,224
Study Case Total	$96,327,392	$106,710,440	$106,710,440
Cape Girardeau			
CORN	$16,745,614	$16,745,614	$16,745,614
SOYBEANS	$12,282,125	$16,376,167	$16,376,167
WHEAT	$6,548,468	$6,548,468	$6,548,468
Study Case Total	$35,576,207	$39,670,249	$39,670,249
Dunklin			
CORN	$10,954,216	$10,954,216	$10,954,216
SOYBEANS	$7,165,472	$9,553,962	$9,553,962

	Day 3	Day 7	Day 14
WHEAT	$7,926,965	$7,926,965	$7,926,965
Study Case Total	$26,378,083	$28,766,574	$28,766,574
Mississippi			
CORN	$4,845,467	$4,845,467	$4,845,467
SOYBEANS	$4,802,039	$6,402,719	$6,402,719
WHEAT	$4,166,135	$4,166,135	$4,166,135
Study Case Total	$13,813,641	$15,414,320	$15,414,320
New Madrid			
CORN	$14,932,637	$14,932,637	$14,932,637
SOYBEANS	$12,307,315	$16,409,753	$16,409,753
WHEAT	$10,900,187	$10,900,187	$10,900,187
Study Case Total	$38,140,139	$42,242,577	$42,242,577
Scott			
CORN	$21,586,429	$21,586,429	$21,586,429
SOYBEANS	$17,522,615	$23,363,487	$23,363,487
WHEAT	$17,928,199	$17,928,199	$17,928,199
Study Case Total	$57,037,244	$62,878,116	$62,878,116
Stoddard			
CORN	$18,853,988	$18,853,988	$18,853,988
SOYBEANS	$13,481,538	$17,975,384	$17,975,384
WHEAT	$13,447,531	$13,447,531	$13,447,531
Study Case Total	$45,783,058	$50,276,904	$50,276,904
Pemiscot			
CORN	$6,374,331	$6,374,331	$6,374,331
SOYBEANS	$5,232,500	$6,976,667	$6,976,667
WHEAT	$5,774,114	$5,774,114	$5,774,114
Total	$17,380,945	$19,125,112	$19,125,112

Table 3.5.1h shows the actual recorded insurance payments due to crop losses in the bootheel region from 2009-2012. These losses are caused by excess moisture and flooding.

Table 3.5.1h Recorded USDA Crop Insurance Losses

County	2009 – 2012 USDA Crop losses to excess moisture	Annualized moisture Losses	2009-2012 USDA crop losses to flood	Annualized flood losses
Bollinger	$614,881	$153,620.25	$33,572	$8,393.00
Butler	$3,946,861	$986,715.25	$282,948	$70,737.00
Cape Girardeau	$3,781,987	$945,496.75	$1,831,267	$457,816.75
Dunklin	$5,168,075	$1,292,018.75	$2,461,346	$615,336.50
Mississippi	$11,753,131	$2,938,282.75	$6,760,390	$1,690,097.50
New Madrid	$7,584,569	$1,896,142.25	$2,086,599	$521,649.75
Pemiscot	$7,767,438	$1,941,859.5	$595,636	$148,909.00
Scott	$4,804,168	$1,201,042	$820,255	$205,063.75
Stoddard	$15,552,958	$3,888,239.5	$2,498,997	$624,749.25
Total	**$60,974,068**	**$15,243,417**	**$17,371,010**	**$4,342,752.50**

Changes in Development for Jurisdictions in Hazard Prone Areas

To determine the jurisdictions that are most vulnerable to flood losses and are also increasing in population and housing units, the top 10 counties at risk to the 100-year flood for building loss, loss ratio, and displaced population were compared against the top 10 counties experiencing population gains and housing gains. Clay County appears in both the top ten lists for population gain, and housing gain. In addition, Clay County is in the top ten for loss ratio, building losses and displaced population. This is the only County that appears on all five lists. Boone, Greene and Jefferson Counties appear on four of the five lists; population change, housing change, building loss and displaced population. Cass County appears on three of the lists; population change, housing change and displaced population.

The counties experiencing the most development pressures all participate in the National Flood Insurance Program, thus flood risk should not be increasing; assuming that floodplain ordinances are being effectively implemented and wise use of floodplains is being encouraged.

3.5.2 Dam Failure

For hazard profile information on dam failure, see Section 3.3.2.

Overview and Analysis of Vulnerability to Dam Failure

Of the approximately 5,000 known dams in the State, there are 682 dams that fall under state–regulation. By definition, state-regulated dams are those dams that are not federally regulated, but that are more than 35 feet in height. Of the 682 state-regulated dams, 203 are class 1, 255 are class 2 and 224 are class 3 dams (see Section 3.3.1 for definition of classes). These classes are determined based on the number of structures in the inundation areas of each dam. Class 1 dams contain ten or more permanent dwellings or any public building, class 2 dams contain one to nine permanent dwellings, or one or more campgrounds with permanent water, sewer, and electrical services and class 3 dams which do not have any permanent dwellings within their inundation area. When considering the Hazard Potential Classifications utilizing the guidelines of the National Inventory of Dams (NID), of the 682 state-regulated dams 370 are considered High Hazard Dams. The NID dam classification definitions are as follows:

- **High Hazard Dam**—A dam located in an area where failure could result in any of the following: extensive loss of life, damage to more than one home, damage to industrial or commercial facilities, interruption of a public utility serving a large number of customers, damage to traffic on high-volume roads that meet the requirements for hazard class C dams or a high-volume railroad line, inundation of a frequently used recreation facility serving a relatively large number of persons, or two or more individual hazards described for significant hazard dams
- **Significant Hazard Dam**—A dam located in an area where failure could endanger a few lives, damage an isolated home, damage traffic on moderate volume roads that meet certain requirements, damage low-volume railroad tracks, interrupt the use or service of a utility serving a small number of customers, or inundate recreation facilities, including campground areas intermittently used for sleeping and serving a relatively small number of persons
- **Low Hazard Dam**—A dam located in an area where failure could damage only farm or other uninhabited buildings, agricultural or undeveloped land including hiking trails, or traffic on low-volume roads that meet the requirements for low hazard dams

There is not a direct correlation between the State Hazard classification (definitions in Section 3.3.2) and the NID classifications. However, most dams that are in the State's Classes 1 and 2 are considered NID High Hazard Potential (HHP) Dams.

There are also 66 federally-regulated dams in Missouri. All federally-regulated dams fall outside the regulatory authority of the Missouri Dam and Reservoir Safety Program. The two federal agencies responsible for most of these dams are the U.S. Army Corps of Engineers (Corps) and the U.S Department of Agriculture Forest Service. There are also dams outside the State of Missouri that could adversely affect the State.

Since detailed data that would be provided in an EAP and associated inundation mapping is still currently underway, the State planning team focused on the State hazard class determinations of the 682 state-regulated dams to provide an overview and analysis of the vulnerability to dam failure in Missouri. The reason for focusing on these dams is that as the entity with regulatory authority, the State has more comprehensive information on these dams to enable consistent analysis. The U.S. Army Corps

of Engineers was contacted to provide inundation zones and/or vulnerability studies completed for the large federal reservoirs under their authority. However, this information was not provided for incorporation in this document. Rationale for not providing the documentation varied by Army Corps District, but was largely due to homeland security concerns. This is an area of coordination that the State recognizes as needing additional attention to secure this information for future State Mitigation Plan Updates.

The National Inventory of Dams is publically available via the following URL: http://geo.usace.army.mil/pgis/f?p=397:3:0::NO::P3_STATES:MO. This website allows users to view a statewide map that shows all dams in the NID. In addition, a number of report charts are provided that specifically present: hazard potential, dams with Emergency Action Plans, dam height, dam owner type, types of dam construction, dam primary purposes, and construction dates.

When considering permits for dam construction, the Missouri Dam Reservoir Safety Program officials consider three classes based on the downstream environment zone or the area downstream from a dam that would be affected by inundation in the event the dam failed. The three classes based on the downstream environment and associated inspection frequencies are set forth in the Rules and Regulations of the Missouri Dam and Reservoir Safety Council. See Section 3.3.2 for definitions of Class 1, 2 and 3 state-regulated dams.

Figure 3.5.2.1, Figure 3.5.2.2 and Figure 3.5.2.3 provide the numbers of state-regulated class 1, class 2 and class 3 dams in Missouri. Those dams considered being as high hazard (class 1 and class 2), are individually listed in Appendix A of the Plan document.

Figure 3.5.2.1 - State-regulated Class 1 Dams by County

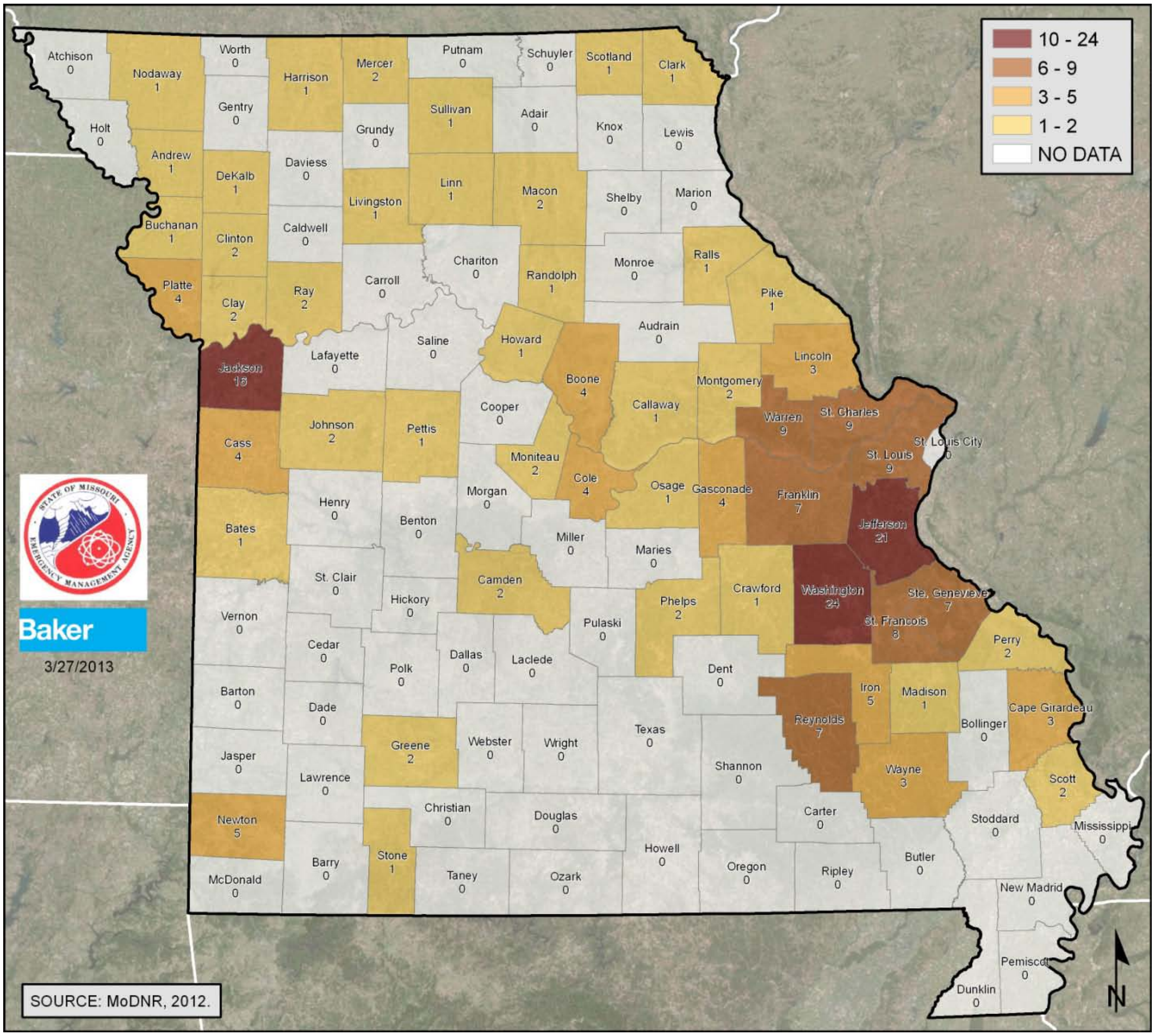


Figure 3.5.2.2 - State-regulated Class 2 Dams by County

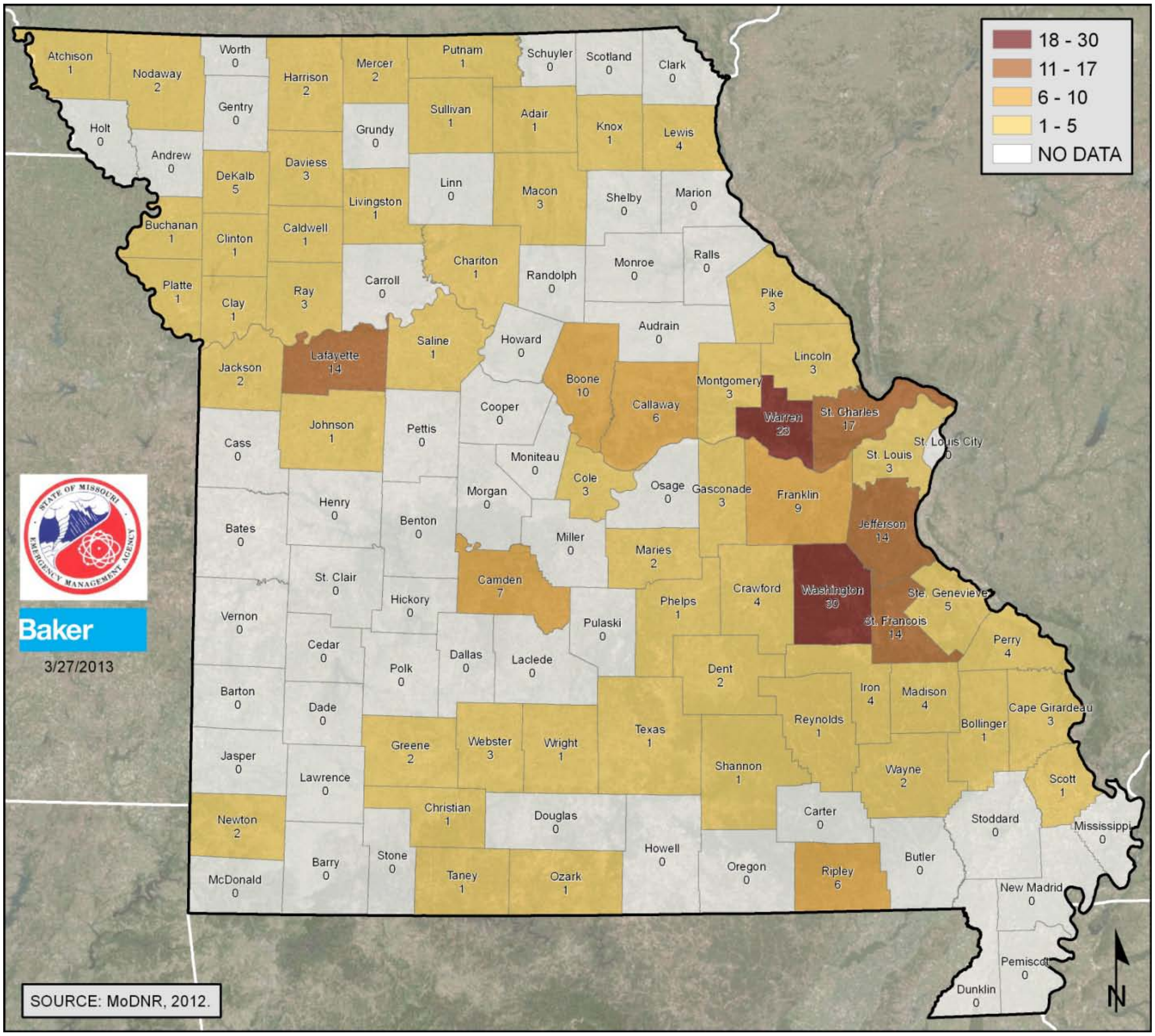
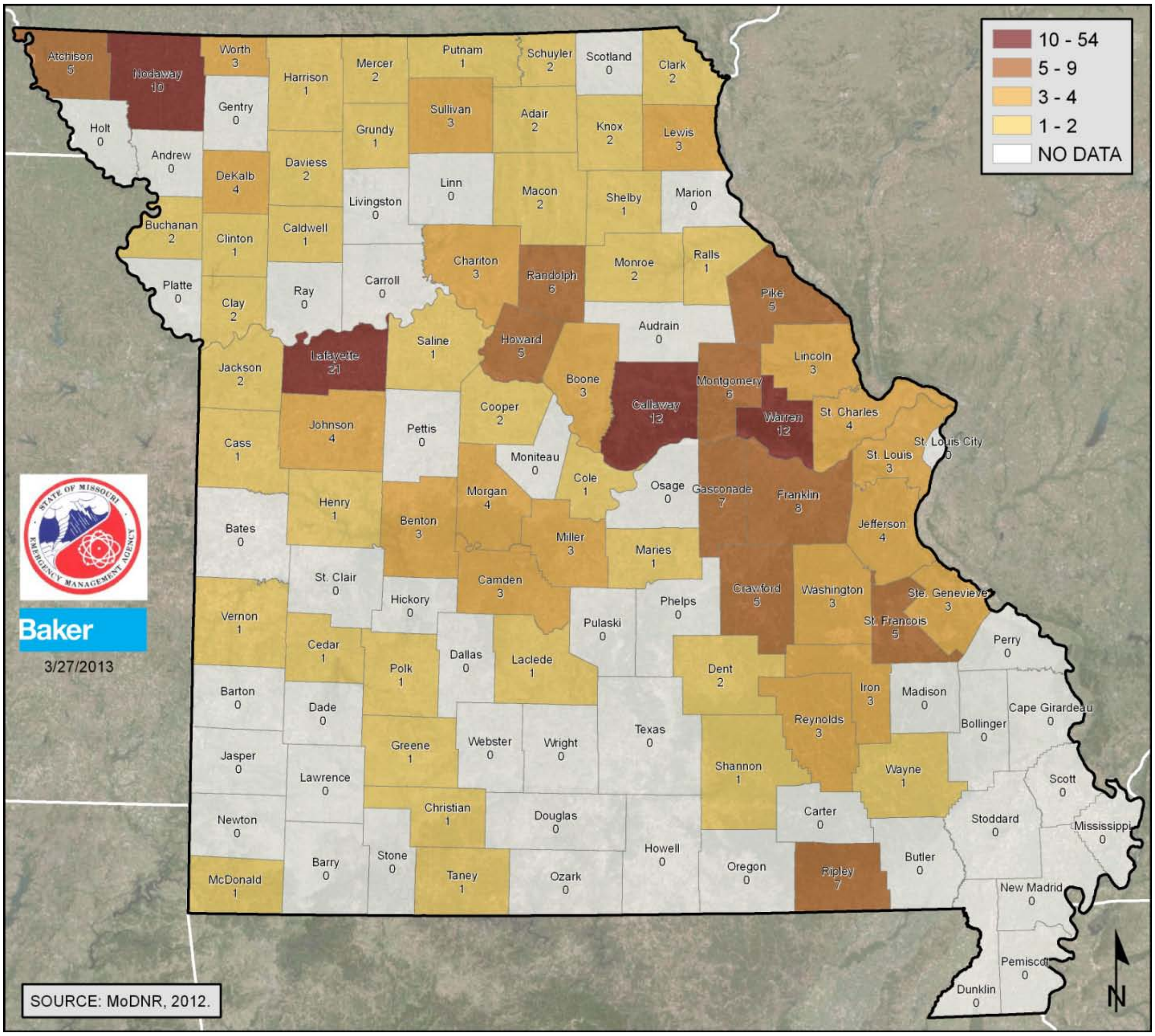


Figure 3.5.2.3 - State-regulated Class 3 Dams by County



From the State hazard class definitions, the State planning team set out the following assumptions for providing a state-wide vulnerability overview:

- For class 1 dams, the number of structures in the inundation area was estimated to be 10 buildings since this is the minimum threshold for a dam being considered a class 1 dam.
- For class 2 dams, the number of structures in the inundation area was estimated to be 5 buildings. This is the mid-range of buildings in the inundation area for a dam to be considered a class 2 dam.
- For class 3 dams, the number of structures in the inundation area was estimated to be 0 buildings since class 3 dams do not have any structures within their inundation area.

Figure 3.5.2.4 provides the resulting number of buildings by county potentially vulnerable to failure of state-regulated dams in Missouri.

Figure 3.5.2.4 - Estimated Number of Buildings Vulnerable to Failure of State-regulated Dams

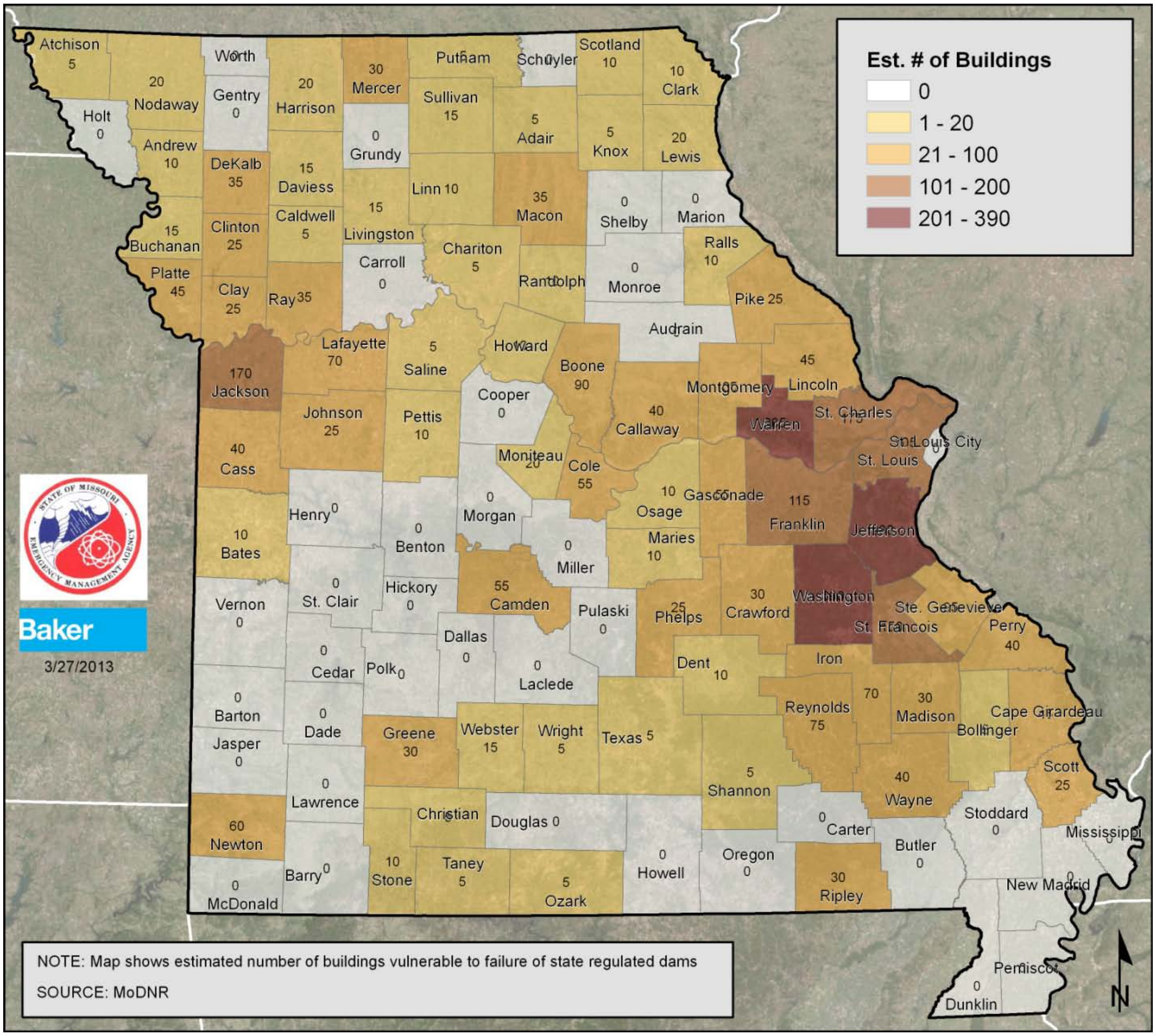


Table 3.5.2a provides the top 12 counties in order of number of estimated buildings vulnerable to failure of state-regulated dams.

Table 3.5.2a Top 12 Counties: Estimated # of Vulnerable Buildings

County	Estimated # of Vulnerable Buildings
Washington	390
Jefferson	280
Warren	205
St. Charles	175

County	Estimated # of Vulnerable Buildings
Jackson	170
St. Francois	150
Franklin	115
St. Louis	105
Ste. Genevieve	95
Boone	90
Reynolds	75
Iron/Lafayette	70

It should be re-iterated that there are nearly 4,500 unregulated dams in the State of Missouri because they do not meet the 35-foot dam height requirement to fall under state regulation. Although failure potential certainly exists for these non-regulated dams, it is very difficult to attempt to analyze vulnerability due to data limitations.

Overview and Analysis of Potential Loss Estimates to Dam Failure

Keeping in mind the same assumptions that were utilized to determine the approximate number of buildings vulnerable to failure of state-regulated dams, the State Hazard Mitigation Planning Team attempted to quantify potential loss estimates in terms of property damages. To complete this analysis, the following additional assumptions were utilized:

- Average values for residential structures were obtained for each county from HAZUS-MH MR4. Residential structures were chosen as the most prevalent structure-type downstream of dams. Although certainly other building types are present, the numbers and values are not known.
- The estimated structure loss was estimated to be at 50 percent of the value of the structure. Actual losses will vary based on the depth of inundation.
- For population exposure, United States Census blocks were intersected with available State regulated dam inundation areas to identify the vulnerable population for each county.

Figure 3.5.2.5 and Figure 3.5.2.6 provide the resulting total estimated building losses and population exposure by county. This analysis indicates that there is a concentration of vulnerability to buildings in the central-eastern counties of Missouri. Table 3.5.2.b that follows provides the top 10 Missouri Counties based on estimated potential building losses and population exposure to failure of state-regulated dams.

SEMA realizes that dam-related information and GIS data sets will continue to improve and evolve in the coming years. As this data becomes available, SEMA intends to leverage it for additional dam failure analysis in future Plan updates.

Figure 3.5.2.5 - Estimated Building Losses from Failure of State-regulated Dams

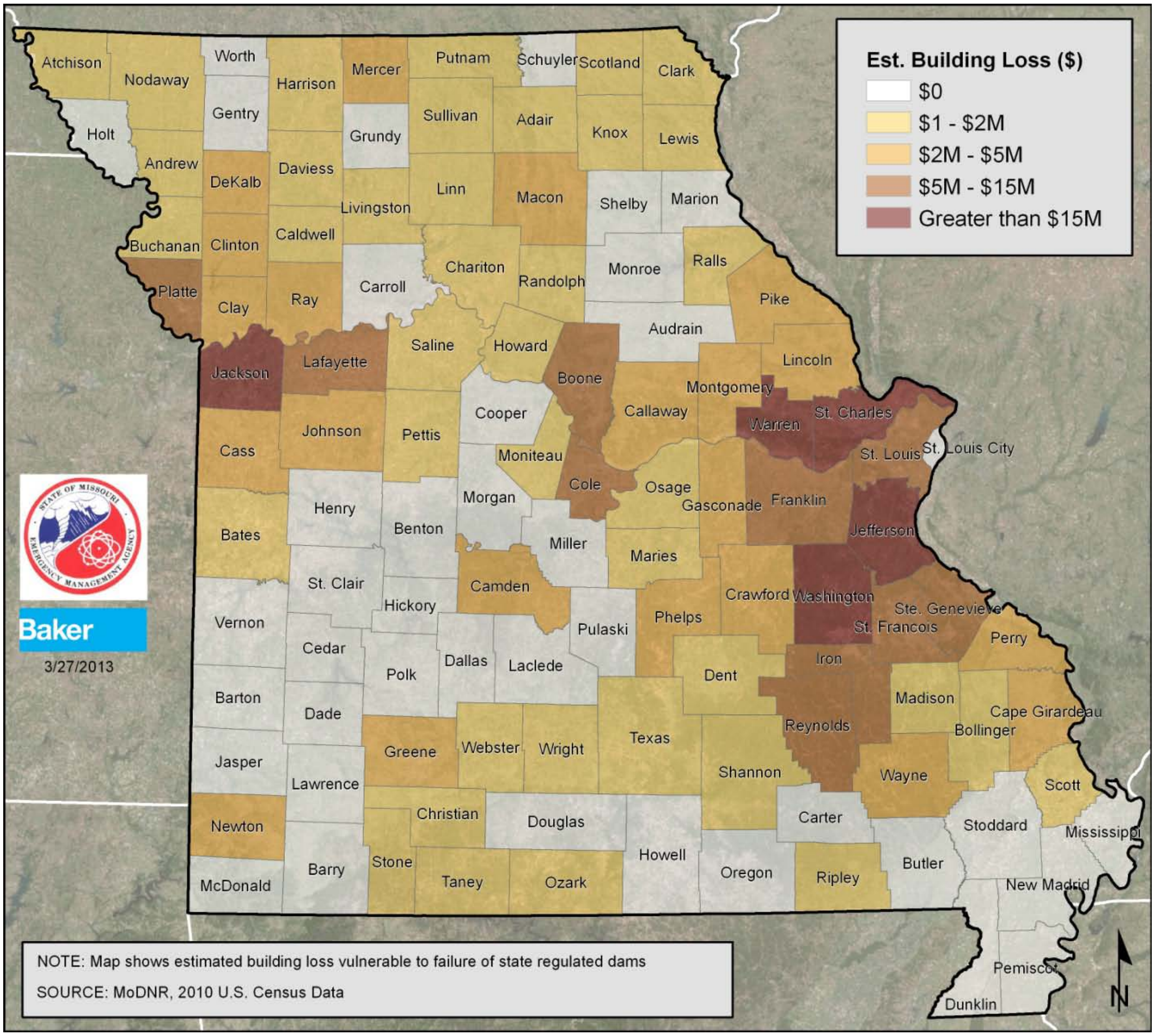


Figure 3.5.2.6 Estimated Population Exposure to Failure of State-regulated Dams

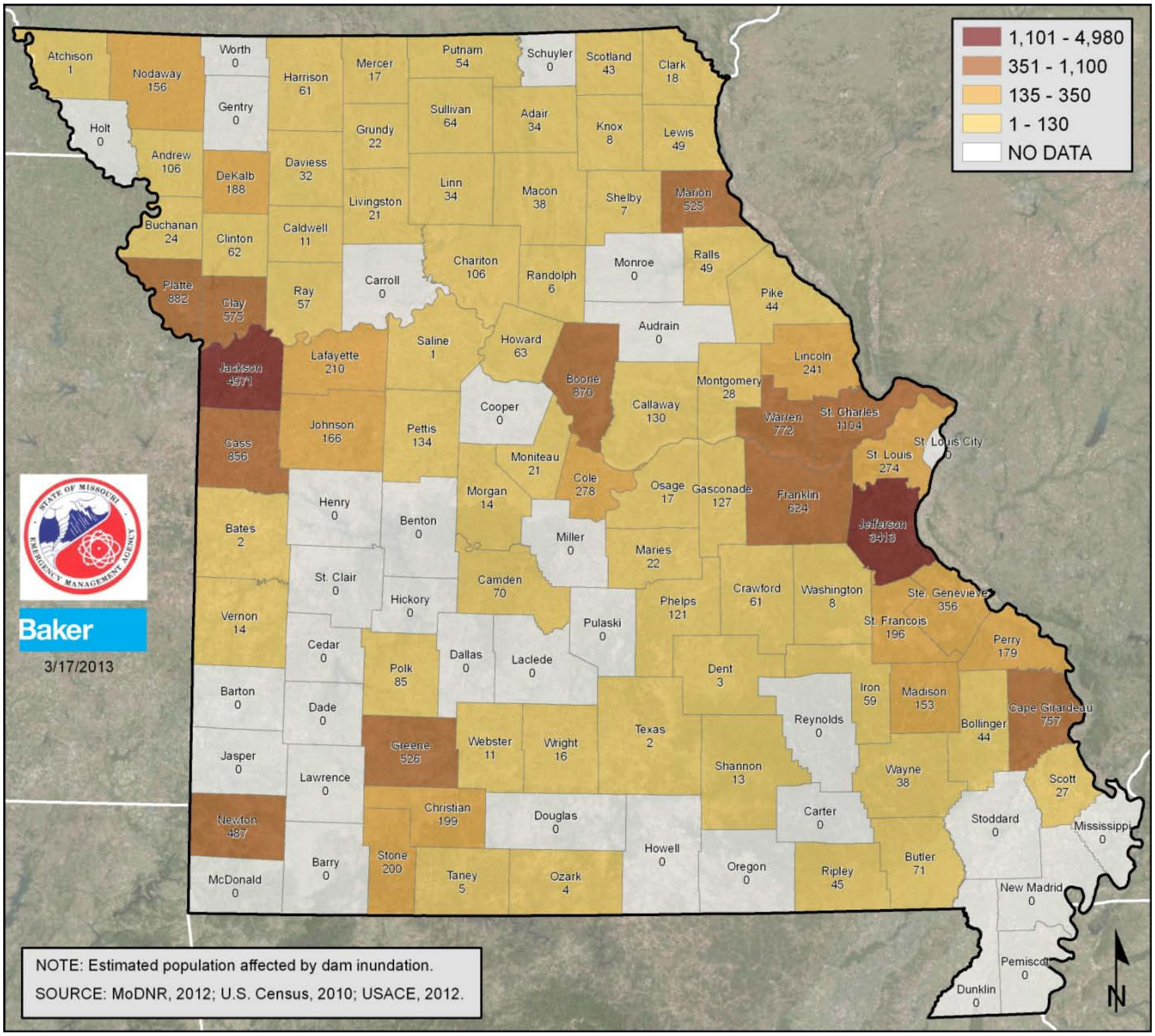


Table 3.5.2b Top 10 Counties: Estimated Building Loss and Estimated Population Exposed to Failure of State-regulated Dams

Top 10 Building Loss	Top 10 Population Exposure
Jefferson	Jackson
Washington	Jefferson
Saint Charles	Saint Charles
Warren	Platte
Jackson	Boone
Saint Francois	Cass

Top 10 Building Loss	Top 10 Population Exposure
Saint Louis	Warren
Franklin	Cape Girardeau
Saint Genevieve	Franklin
Boone	Clay

Table 3.5.2c provides the summary data of the described analysis.

Table 3.5.2c County-by County Vulnerability Analysis for Failure of State-regulated Dams in Missouri

County	Class 1	Class 2	Class 3	Total	Estimated # of Buildings Vulnerable	Average Exposure Value per Structure ($)	Estimated Total Potential Building Exposure ($)	Estimated Total Population Exposure	Estimated Building Losses ($)
Adair	0	1	2	3	5	97,920	1,466,363	34	733,182
Andrew	1	0	0	1	10	119,115	1,850,783	106	925,391
Atchison	0	1	5	6	5	60,218	815,137	1	407,568
Audrain	0	0	0	0	0	95,265	0	0	0
Barry	0	0	0	0	0	68,608	0	0	0

County	Class 1	Class 2	Class 3	Total	Estimated # of Buildings Vulnerable	Average Exposure Value per Structure ($)	Estimated Total Potential Building Exposure ($)	Estimated Total Population Exposure	Estimated Building Losses ($)
Barton	0	0	0	0	0	74,990	0	0	0
Bates	1	0	0	1	10	73,703	1,685,333	2	842,666
Benton	0	0	3	3	0	67,934	0	0	0
Bollinger	0	1	0	1	5	76,650	704,223	44	352,112
Boone	4	10	3	17	90	140,937	17,003,324	870	8,501,662
Buchanan	1	1	2	4	15	127,278	2,724,015	24	1,362,008
Butler	0	0	0	0	0	72,468	0	71	0
Caldwell	0	1	1	2	5	69,411	832,544	11	416,272

County	Class 1	Class 2	Class 3	Total	Estimated # of Buildings Vulnerable	Average Exposure Value per Structure ($)	Estimated Total Potential Building Exposure ($)	Estimated Total Population Exposure	Estimated Building Losses ($)
Callaway	1	6	12	19	40	106,696	6,711,773	130	3,355,887
Camden	2	7	3	12	55	106,665	8,634,997	70	4,317,499
Cape Girardeau	3	3	0	6	45	126,368	7,706,466	757	3,853,233
Carroll	0	0	0	0	0	79,678	0	0	0
Carter	0	0	0	0	0	67,602	0	0	0
Cass	4	0	1	5	40	140,193	9,139,766	856	4,569,883
Cedar	0	0	1	1	0	76,300	0	0	0
Chariton	0	1	3	4	5	70,102	789,689	106	394,845
Christian	0	1	1	2	5	100,321	873,537	199	436,769
Clark	1	0	2	3	10	69,894	1,417,803	18	708,901
Clay	2	1	2	5	25	169,633	5,432,805	575	2,716,402
Clinton	2	1	1	4	25	122,538	5,074,802	62	2,537,401
Cole	4	3	1	8	55	139,433	10,791,452	278	5,395,726
Cooper	0	0	2	2	0	93,970	0	0	0
Crawford	1	4	5	10	30	84,827	4,403,472	61	2,201,736
Dade	0	0	0	0	0	68,226	0	0	0
Dallas	0	0	0	0	0	75,059	0	0	0
Daviess	0	3	2	5	15	63,609	2,499,716	32	1,249,858
DeKalb	1	5	4	10	35	82,530	6,049,514	188	3,024,757
Dent	0	2	2	4	10	78,112	1,527,519	3	763,759
Douglas	0	0	0	0	0	71,859	0	0	0
Dunklin	0	0	0	0	0	66,747	0	0	0
Franklin	7	9	8	24	115	120,628	21,236,716	624	10,618,358

County	Class 1	Class 2	Class 3	Total	Estimated # of Buildings Vulnerable	Average Exposure Value per Structure ($)	Estimated Total Potential Building Exposure ($)	Estimated Total Population Exposure	Estimated Building Losses ($)
Gasconade	4	3	7	14	55	82,323	9,091,906	127	4,545,953
Gentry	0	0	0	0	0	61,376	0	0	0
Greene	2	2	1	5	30	122,854	4,946,104	526	2,473,052
Grundy	0	0	1	1	0	75,390	0	22	0
Harrison	1	2	1	4	20	68,442	3,490,461	61	1,745,231
Henry	0	0	1	1	0	86,893	0	0	0
Hickory	0	0	0	0	0	59,466	0	0	0
Holt	0	0	0	0	0	65,105	0	0	0
Howard	1	0	5	6	10	92,094	1,650,626	63	825,313
Howell	0	0	0	0	0	71,405	0	0	0
Iron	5	4	3	12	70	68,210	10,012,705	59	5,006,353
Jackson	16	2	2	20	170	161,696	32,699,488	497 1	16,349,744
Jasper	0	0	0	0	0	92,841	0	0	0
Jefferson	21	14	4	39	280	130,491	55,516,510	341 3	27,758,255
Johnson	2	1	4	7	25	114,927	4,551,774	166	2,275,887
Knox	0	1	2	3	5	61,489	700,177	8	350,089
Laclede	0	0	1	1	0	86,388	0	0	0
Lafayette	0	14	21	35	70	104,284	13,331,453	210	6,665,727
Lawrence	0	0	0	0	0	78,871	0	0	0
Lewis	0	4	3	7	20	66,813	2,958,749	49	1,479,375
Lincoln	3	3	3	9	45	108,582	7,866,637	241	3,933,318
Linn	1	0	0	1	10	71,514	1,543,212	34	771,606
Livingston	1	1	0	2	15	86,791	2,237,753	21	1,118,876
Macon	2	3	2	7	35	74,586	5,124,803	38	2,562,402
Madison	1	4	0	5	30	76,034	3,998,180	153	1,999,090

County	Class 1	Class 2	Class 3	Total	Estimated # of Buildings Vulnerable	Average Exposure Value per Structure ($)	Estimated Total Potential Building Exposure ($)	Estimated Total Population Exposure	Estimated Building Losses ($)
Maries	0	2	1	3	10	79,216	1,588,349	22	794,174
Marion	0	0	0	0	0	104,074	0	525	0
McDonald	0	0	1	1	0	60,333	0	0	0
Mercer	2	2	2	6	30	65,965	4,366,026	17	2,183,013
Miller	0	0	3	3	0	82,166	0	0	0
Mississippi	0	0	0	0	0	75,459	0	0	0
Moniteau	2	0	0	2	20	85,461	3,448,525	21	1,724,262
Monroe	0	0	2	2	0	70,705	0	0	0
Montgomery	2	3	6	11	35	93,275	5,362,186	28	2,681,093
Morgan	0	0	4	4	0	75,188	0	14	0
New Madrid	0	0	0	0	0	72,925	0	0	0
Newton	5	2	0	7	60	89,508	9,089,122	487	4,544,561
Nodaway	1	2	10	13	20	87,251	3,009,728	156	1,504,864
Oregon	0	0	0	0	0	61,128	0	0	0
Osage	1	0	0	1	10	88,095	1,767,931	17	883,965
Ozark	0	1	0	1	5	61,833	599,290	4	299,645
Pemiscot	0	0	0	0	0	68,740	0	0	0
Perry	2	4	0	6	40	104,258	7,483,027	179	3,741,513
Pettis	1	0	0	1	10	94,014	1,700,203	134	850,101
Phelps	2	1	0	3	25	99,375	4,060,822	121	2,030,411
Pike	1	3	5	9	25	83,949	4,228,494	44	2,114,247
Platte	4	1	0	5	45	181,530	10,359,144	882	5,179,572
Polk	0	0	1	1	0	83,346	0	85	0
Pulaski	0	0	0	0	0	120,886	0	0	0
Putnam	0	1	1	2	5	57,695	688,587	54	344,293
Ralls	1	0	1	2	10	81,303	1,644,855	49	822,427

County	Class 1	Class 2	Class 3	Total	Estimated # of Buildings Vulnerable	Average Exposure Value per Structure ($)	Estimated Total Potential Building Exposure ($)	Estimated Total Population Exposure	Estimated Building Losses ($)
Randolph	1	0	6	7	10	91,896	1,543,937	6	771,968
Ray	2	3	0	5	35	117,271	7,135,325	57	3,567,663
Reynolds	7	1	3	11	75	70,330	10,257,206	0	5,128,603
Ripley	0	6	7	13	30	63,749	36,83,711	45	1,841,855
Saline	0	1	1	2	175	95,136	39,789,608	1	19,894,804
Schuyler	0	0	2	2	0	50,897	0	0	0
Scotland	1	0	0	1	150	66,429	24,809,047	43	12,404,524
Scott	2	1	0	3	105	90,709	23,658,740	27	11,829,370
Shannon	0	1	1	2	0	62,916	0	13	0
Shelby	0	0	1	1	95	61,222	17,266,074	7	8,633,037
St. Charles	9	17	4	30	5	166,592	860,788	110 4	430,394
St. Clair	0	0	0	0	0	62,561	0	0	0
St. Francois	8	14	5	27	10	93,652	1,515,119	196	757,560
St. Louis	0	0	0	0	25	179,585	3,927,618	0	1,963,809
St. Louis City*	9	3	3	15	5	178,477	773,096	274	386,548
Ste. Genevieve	7	5	3	15	0	114,683	0	356	0
Stoddard	0	0	0	0	0	74,410	0	0	0
Stone	1	0	0	1	10	79,053	1,510,115	200	755,058
Sullivan	1	1	3	5	15	60,050	1,887,331	64	943,665
Taney	0	1	1	2	5	86,642	643,980	5	321,990
Texas	0	1	0	1	5	73,006	691,004	2	345,502
Vernon	0	0	1	1	0	83,163	0	14	0
Warren	9	23	12	44	205	109,783	36,220,896	772	18,110,448
Washington	24	30	3	57	390	71,570	51,635,370	8	25,817,685
Wayne	3	2	1	6	40	66,912	4,985,572	38	2,492,786

County	Class 1	Class 2	Class 3	Total	Estimated # of Buildings Vulnerable	Average Exposure Value per Structure ($)	Estimated Total Potential Building Exposure ($)	Estimated Total Population Exposure	Estimated Building Losses ($)
Webster	0	3	0	3	15	85,091	2,359,561	11	1,179,781
Worth	0	0	3	3	0	60,894	0	0	0
Wright	0	1	0	1	5	74,621	676,753	16	338,376

Source: MO DNR Dam and Reservoir Safety Program; U.S. Census Bureau, Census 2000-average residential value and average residential occupancy

It should be noted that dam failures are generally isolated incidents and do not often occur in conjunction with failure at additional dam sites. Since it is unknown which dams, if any might fail at any given time, this analysis provides for a state-wide view of dam failure. It is nearly certain that not all state-regulated dams would fail simultaneously. So, this analysis should be viewed in light of these considerations.

Changes in Development for Jurisdictions in Hazard Prone Areas

Chapter 5, Coordination of Local Mitigation Planning, provides a detailed methodology for local jurisdictions to follow to prepare more accurate vulnerability analysis from available inundation maps. As the State is still in the stages of a concentrated effort to have inundation maps and Emergency Action Plans completed for all high hazard potential dams, provision of this methodology to local planners is aimed at providing a consistent method to apply to analysis of dam failure vulnerability.

3.5.3 Levee Failure

For hazard profile information for levee failure, see Section 3.3.3.

Overview and Analysis of Vulnerability to Levee Failure

The analysis and discussion of vulnerability to levee failure in this plan is for levees indicated as providing protection from 100-year or higher base flood level. Levees that provide protection from more frequent, lower-level flooding would overtop in a 100-year event; resulting loss estimates are captured in the discussion of vulnerability to riverine flooding in Section 3.5.1.

Levees have been constructed across the State of Missouri by public entities and private entities with varying levels of protection, inspection oversight and maintenance. The National Levee Safety Program Act of 2007 directed the development of a national levee safety program, in addition to the inventory and inspection of levees. As discussed in Section 3.3.3, two concurrent nation-wide levee inventory development efforts led by USACE and FEMA have captured the majority of levees in the State of Missouri, with the NLD focusing on the Corps' active PL84-99 program levees and the MLI focusing on levees that provide protection from 100-year or higher base flood level. In fall of 2012, USACE and FEMA conducted a pilot project to integrate the NLD and MLI levees for FEMA Region VII, which covers the entire State of Missouri. As a result of the pilot, Missouri now has a comprehensive levee GIS inventory that is spatially accurate and that reflects the best available information about levees from both federal agencies. This data will be used for high-level levee failure vulnerability analysis. Table 3.1 is a summary of levee systems in the State of Missouri known to provide protection from 100-year or higher base flood.

Table 3.5.3a Known Levees in Missouri With Reference to Providing 100-year of Greater Flood Protection

County	Accreditation Status	USACE Levee Safety Prog.	Fed Const.	Name	Length (miles)	City	River	Protected Area	Protected Area Size	Level of Protection
Andrew	De-accredited	Yes	Yes	MRLS 476-L	10.8	AG	Missouri	Agriculture	5 - 24 square miles	100 - 500 year flood
Atchison	Not PAL Eligible	Yes	Yes	MR :-536, L-550, L-561 Atchison Co. LD#1	54.2	N/A	Missouri	Agriculture	25 - 49 square miles	100 - 500 year flood
Atchison	Not PAL Eligible	Yes	Yes	MR L-575 NW Atchinson Co. LD	7.29	N/A	Missouri	Agriculture	25 - 49 square miles	100 - 500 year flood
Atchison	Not PAL Eligible	Yes	Yes	MR L-575, Buchannan DD #1	4.55	N/A	Missouri	Agriculture	25 - 49 square miles	100 - 500 year flood
Bollinger	Not PAL Eligible	N/A	Yes	St. Francis River Basin	1.2	N/A	St. Francis River	Agriculture	Greater than 100 square miles	100 - 500 year flood
Buchanan	PAL	N/A	Yes	MRLS 448-443-L	17.3	AG	Missouri	Agriculture	5 - 24 square miles	100 - 500 year flood
Buchanan	PAL	N/A	Yes	MRLS 455-L	15.6	St. Joseph	Missouri	Agriculture	5 - 24 square miles	100 - 500 year flood
Butler	PAL	N/A	Yes	Butler County Drainage No. 12	4.4	Poplar Bluff	Black	Urban	Less than 5 square miles	Greater than 500 year flood
Butler	Not PAL Eligible	N/A	N/A	Levee of St. Francis River	N/A	N/A	N/A	N/A	N/A	N/A
Cape Girardeau	Not PAL Eligible	N/A	N/A	Little River Headwater Diversion Levee 0/2+00 to 19/36+00	N/A	N/A	N/A	N/A	N/A	N/A
Cape Girardeau	PAL	N/A	Yes	Main & N Main St Levee	1.5	Cape Girardeau	Mississippi	Urban	Less than 5 square miles	100 - 500 year flood

County	Accreditation Status	USACE Levee Safety Prog.	Fed Const.	Name	Length (miles)	City	River	Protected Area	Protected Area Size	Level of Protection
Clark	PAL	N/A	Yes	Des Moines and Mississippi Levee District No. 1	15.5	Alexandria	Des Moines River	Agriculture	5 - 24 square miles	100 - 500 year flood
Clay	PAL	N/A	Yes	Birmingham Unit	11.03	Kansas City	Big Shoal Creek	Agriculture	5 - 24 square miles	100 - 500 year flood
Clay	Accredited	N/A	Yes	North Kansas City Levee Unit	2.5	Kansas City/North Kansas City	Missouri	Urban	Less than 5 square miles	100 - 500 year flood
Clay	PAL	N/A	Yes	North Kansas City Levee Unit	6.3	North Kansas City/Kansas City	Missouri	Urban	Less than 5 square miles	100 - 500 year flood
Dunklin	Not PAL Eligible	N/A	Yes	St. Francis River Basin	2.8	NA	St. Francis River	Agriculture	Greater than 100 square miles	100 - 500 year flood
Dunklin	Not PAL Eligible	N/A	Yes	St. Francis River Basin	4.2	NA	St. Francis River	Agriculture	Greater than 100 square miles	100 - 500 year flood
Dunklin	Not PAL Eligible	N/A	Yes	St. Francis River Basin	18.2	NA	St. Francis River	Agriculture	Greater than 100 square miles	100 - 500 year flood
Dunklin	Not PAL Eligible	N/A	Yes	St. Francis River Basin	15.1	NA	St. Francis River	Agriculture	Greater than 100 square miles	100 - 500 year flood
Dunklin	Not PAL Eligible	N/A	Yes	St. Francis River Basin	16.6	NA	St. Francis River	Agriculture	Greater than 100 square miles	100 - 500 year flood

County	Accreditation Status	USACE Levee Safety Prog.	Fed Const.	Name	Length (miles)	City	River	Protected Area	Protected Area Size	Level of Protection
Dunklin	Not PAL Eligible	N/A	Yes	St. Francis River Basin	16.9	NA	St. Francis River	Agriculture	Greater than 100 square miles	100 - 500 year flood
Franklin	PAL	N/A	Yes	New Haven	0.42	New Haven	Missouri	Urban	Less than 5 square miles	100 - 500 year flood
Holt	Not PAL Eligible	N/A	Yes	MRLS 488-L (Holt County District No. 7)	11.5	AG	Missouri	Agriculture	5 - 24 square miles	100 - 500 year flood
Holt	Not PAL Eligible	N/A	Yes	MRLS 497-L	16	AG	Missouri	Agriculture	5 - 24 square miles	100 - 500 year flood
Jackson	PAL	N/A	Yes	CID, Central Industrial District	1.53	Kansas City	Missouri River	Urban	Less than 5 square miles	100 - 500 year flood
Jackson	PAL	N/A	Yes	East Bottoms Unit	9.23	Kansas City	Missouri	Urban	5 - 24 square miles	100 - 500 year flood
Jackson	Accredited	N/A	Yes	GSA Bannister Complex	1.74	GSA Bannister Facility	Blue River	Urban	Less than 5 square miles	100 - 500 year flood
Jackson	PAL	N/A	Yes	Lake City AAP	3.6	Lake City	Fire Prairie Creek	Urban	Less than 5 square miles	100 - 500 year flood
Jackson	PAL	N/A	Yes	MRLS 351-R, Section 1	13	AG	Missouri	Agriculture	5 - 24 square miles	100 - 500 year flood
Jackson	PAL	N/A	Yes	MRLS 351-R, Section 2	2.94	AG	Missouri	Agriculture	5 - 24 square miles	100 - 500 year flood
Jasper	Potential PAL	N/A	Yes	Jasper County Levee	1.1	Carthage	Spring	Agriculture	Less than 5 square miles	Greater than 500 year flood
Lewis	PAL	N/A	Yes	Canton	3.1	Canton	Mississippi	Urban	Less than 5 square miles	100 - 500 year flood

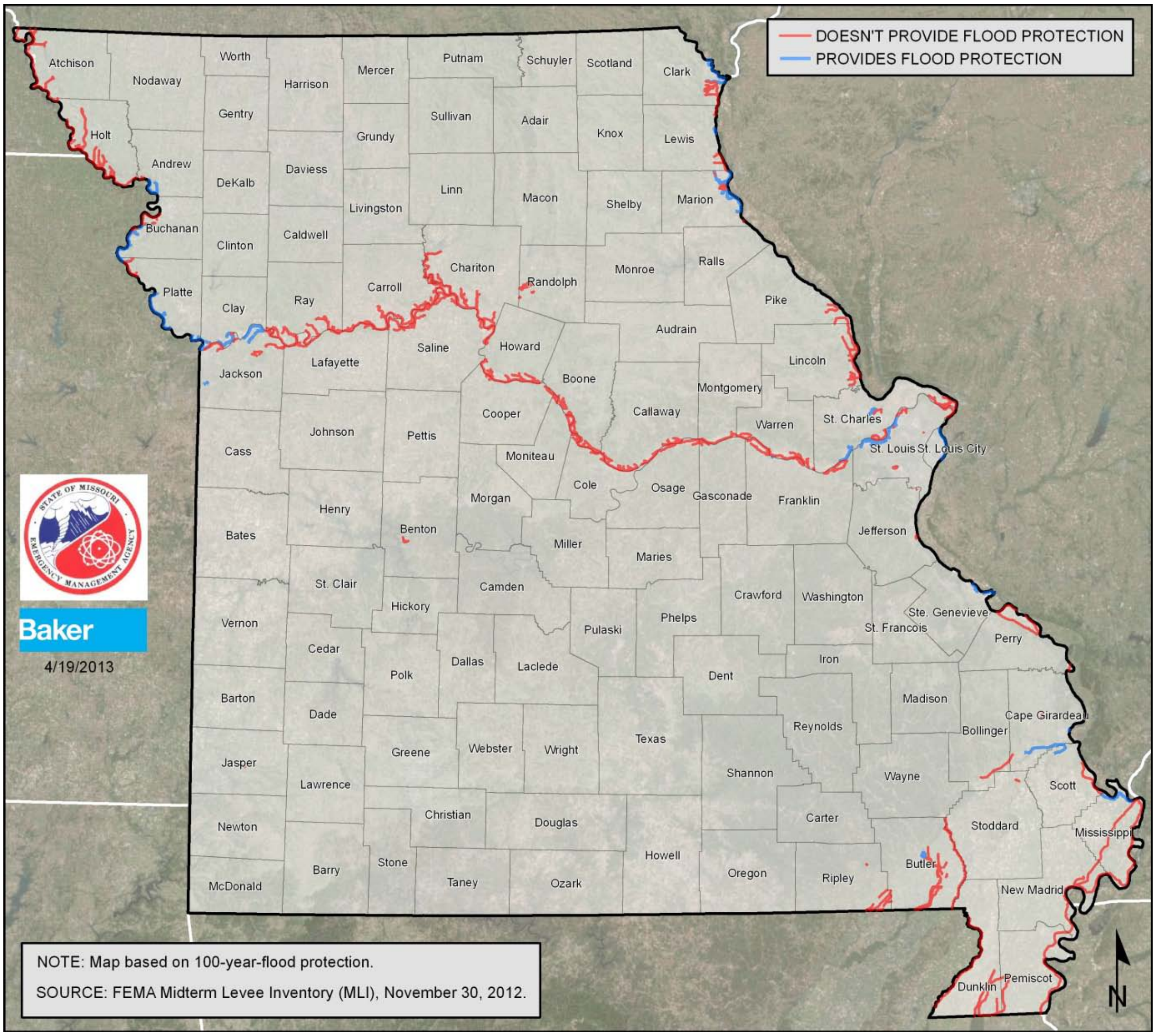
County	Accreditation Status	USACE Levee Safety Prog.	Fed Const.	Name	Length (miles)	City	River	Protected Area	Protected Area Size	Level of Protection
Marion	Accredited	N/A	Yes	Hannibal	0.7	Hannibal	N/A	Urban	Less than 5 square miles	100 - 500 year flood
Mississippi	Not PAL Eligible	N/A	Yes	MS River Levees RB	12.5	NA	Mississippi River	Agriculture	75 - 100 square miles	100 - 500 year flood
Mississippi	Not PAL Eligible	N/A	Yes	MS River Levees RB	14.2	Charleston, MO	Mississippi River	Agriculture	Greater than 100 square miles	100 - 500 year flood
New Madrid	Not PAL Eligible	N/A	Yes	MS River Levees RB	22.7	NA	Mississippi River	Agriculture	Greater than 100 square miles	100 - 500 year flood
New Madrid	Not PAL Eligible	N/A	Yes	MS River Levees RB	9.8	NA	Mississippi River	Agriculture	Greater than 100 square miles	100 - 500 year flood
New Madrid	Not PAL Eligible	N/A	Yes	MS River Levees RB	1.9	New Madrid, MO	Mississippi River	Agriculture	Greater than 100 square miles	100 - 500 year flood
Pemiscot	Not PAL Eligible	N/A	Yes	MS River Levees RB	45.9	Caruthersville, MO	Mississippi River	Agriculture	Greater than 100 square miles	100 - 500 year flood
Pike	Not PAL Eligible	N/A	No	Stone-Murdock	1.8	None	Mississippi	Agriculture	Less than 5 square miles	100 - 500 year flood
Platte	PAL	N/A	Yes	MRLS 385-L	5.5	Riverside	Missouri	Urban	Less than 5 square miles	100 - 500 year flood
Platte	PAL	N/A	Yes	MRLS 400-L	7.6	AG	Missouri	Agriculture	5 - 24 square miles	100 - 500 year flood
Platte	PAL	N/A	Yes	MRLS 408-L	12.2	AG	Missouri	Agriculture	5 - 24 square miles	100 - 500 year flood

County	Accreditation Status	USACE Levee Safety Prog.	Fed Const.	Name	Length (miles)	City	River	Protected Area	Protected Area Size	Level of Protection
St. Charles	Not PAL Eligible	N/A	No	Darst Bottom Sec 2	8.2	None	Missouri	Agriculture	5 - 24 square miles	100 - 500 year flood
St. Charles	Accredited	N/A	No	St. Peters Dardenne	4.5	St. Peters	Missouri	Urban	Less than 5 square miles	100 - 500 year flood
St. Charles	De-accredited	N/A	N/A	O'Fallon & Unincorp.	N/A	N/A	N/A	N/A	N/A	N/A
St. Charles	De-accredited	N/A	N/A	Unincorporated Areas	N/A	N/A	N/A	N/A	N/A	N/A
Ste. Genevieve	Accredited	N/A	Yes	Ste Gen Count LD#3	10	Ste. Genevieve	Mississippi	Urban	5 - 24 square miles	100 - 500 year flood
St. Louis	Accredited	N/A	No	Chesterfield Monarch	11.7	Chesterfield	Missouri	Urban	5 - 24 square miles	100 - 500 year flood
St. Louis	Accredited	N/A	No	Earth City	5.5	Earth City	Missouri	Urban	Less than 5 square miles	100 - 500 year flood
St. Louis	Accredited	N/A	No	Howard Bend	6.1	None	Missouri	Urban	5 - 24 square miles	100 - 500 year flood
St. Louis	Accredited	N/A	No	Riverport D& LD	1	None	Missouri	Urban	Less than 5 square miles	100 - 500 year flood
St. Louis	Accredited	N/A	Yes	St. Louis Project	9.9	St. Louis	Mississippi	Urban	5 - 24 square miles	100 - 500 year flood
Scott	Accredited	N/A	Yes	MS River Levees RB	13.8	NA	Mississippi River	Agriculture	Greater than 100 square miles	100 - 500 year flood
Scott	Accredited	N/A	Yes	MS River Levees RB	19.3	NA	Mississippi River	Agriculture	Greater than 100 square miles	100 - 500 year flood

Source: Table compiled from lists provided by the US Army Corps of Engineers and FEMA

The map in Figure 3.5.3.1 depicts locations of levees in Missouri. The integrated MLI-NLD dataset is used for the geometry of the levees and the map is symbolized to distinguish between levees that provide protection against 100 year flood and levees that provide lower levels of flood protection. The red lines indicate levees that do not provide flood protection, while blue lines indicate levees that do provide flood protection.

Figure 3.5.3.1 Levee Locations in Missouri



As part of the map modernization process, FEMA requires levee owners seeking recognition of 100-year or greater flood protection on the Digital Flood Insurance Rate Map to provide proof that levees do indeed meet the levee requirements of 44 CFR 65.10. This levee accreditation process ensures that properties shown as protected by a levee are indeed provided the level of protection as indicated on the DFIRM. Please refer to the map in Section 3.3.3 that shows the Missouri Counties in the process of receiving DFIRMS that have levees being considered for accreditation.

To determine the population and building count vulnerable to damage if these levee segments were to fail, the “Area Protected by Levees” feature class from the FEMA Midterm Levee Inventory was overlaid on census block –level buildings and population data from US Census 2010. As the vulnerability analysis of levee failure in this plan is limited to levees indicated as providing protection from 100-year or higher base flood level, protected area polygons were extracted for levees with a stated level of protection for the 100-year flood or greater. The overlay was performed using proportional division (so that if the levee protected area covers a fraction of a census block, that fraction of the building or population data is counted in the exposure), the building and contents value, building count and population exposure was calculated.

While the levee program has made extraordinary progress, there are still limitation and gaps in the data available. The study information for MO did not have inland levee protection information other than those listed on the major rivers. From this analysis, it was determined that the population in the levee protected area is approximately 993,529 people. The residential building exposure count in the levee protected area is 63,600 buildings.

Maps in Figure 3.5.3.2 and Figure 3.5.3.3 provide the results by county. The population numbers listed in each county represent the population exposed to flooding risk due levees that do not provide flood protection. The red and blue lines still depict whether the levee will provide flood protection.

Figure 3.5.3.2 - Population Exposure: Missouri Levees in USACE Levee Safety Program Providing 100-year or Greater Flood Protection

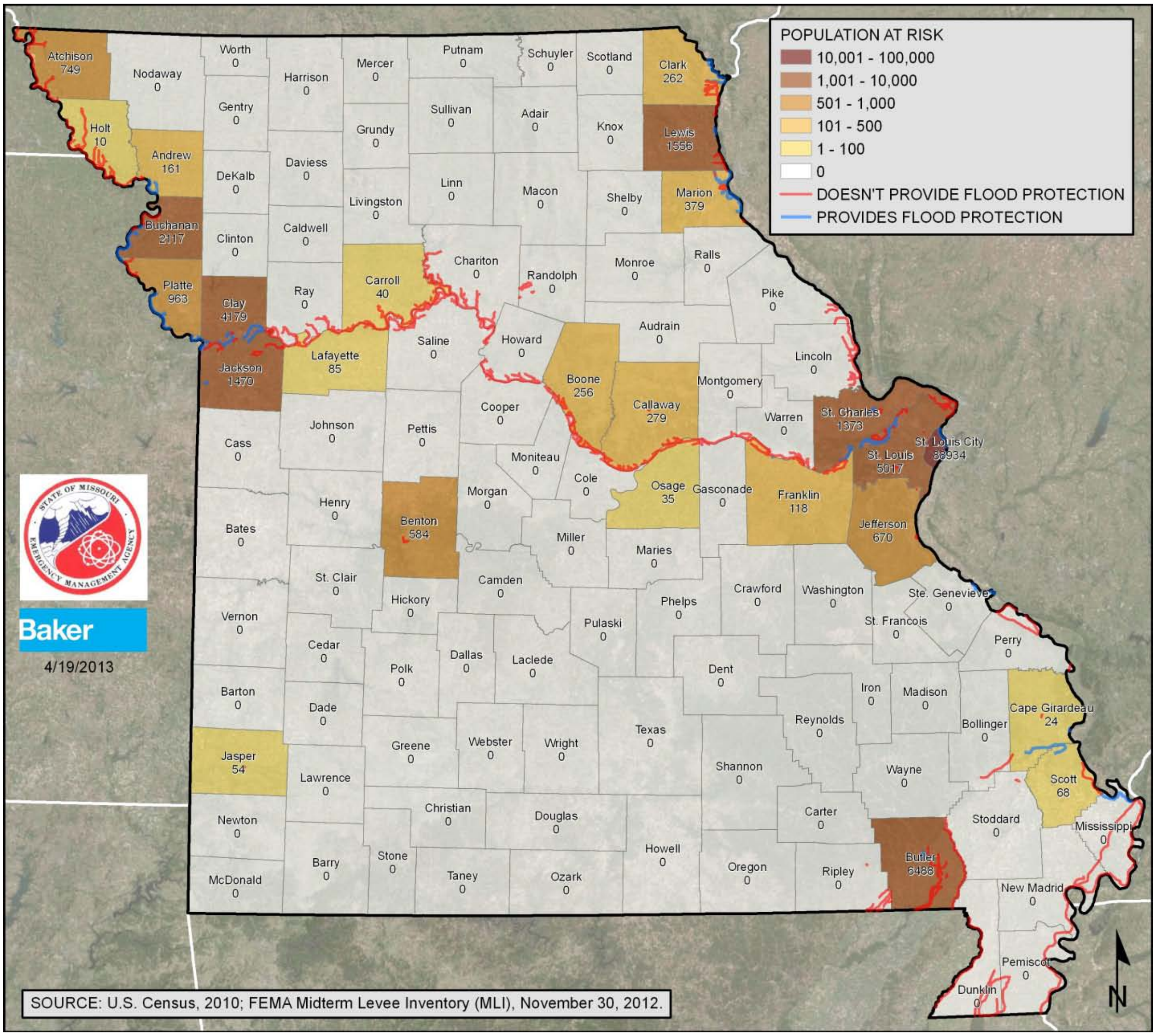
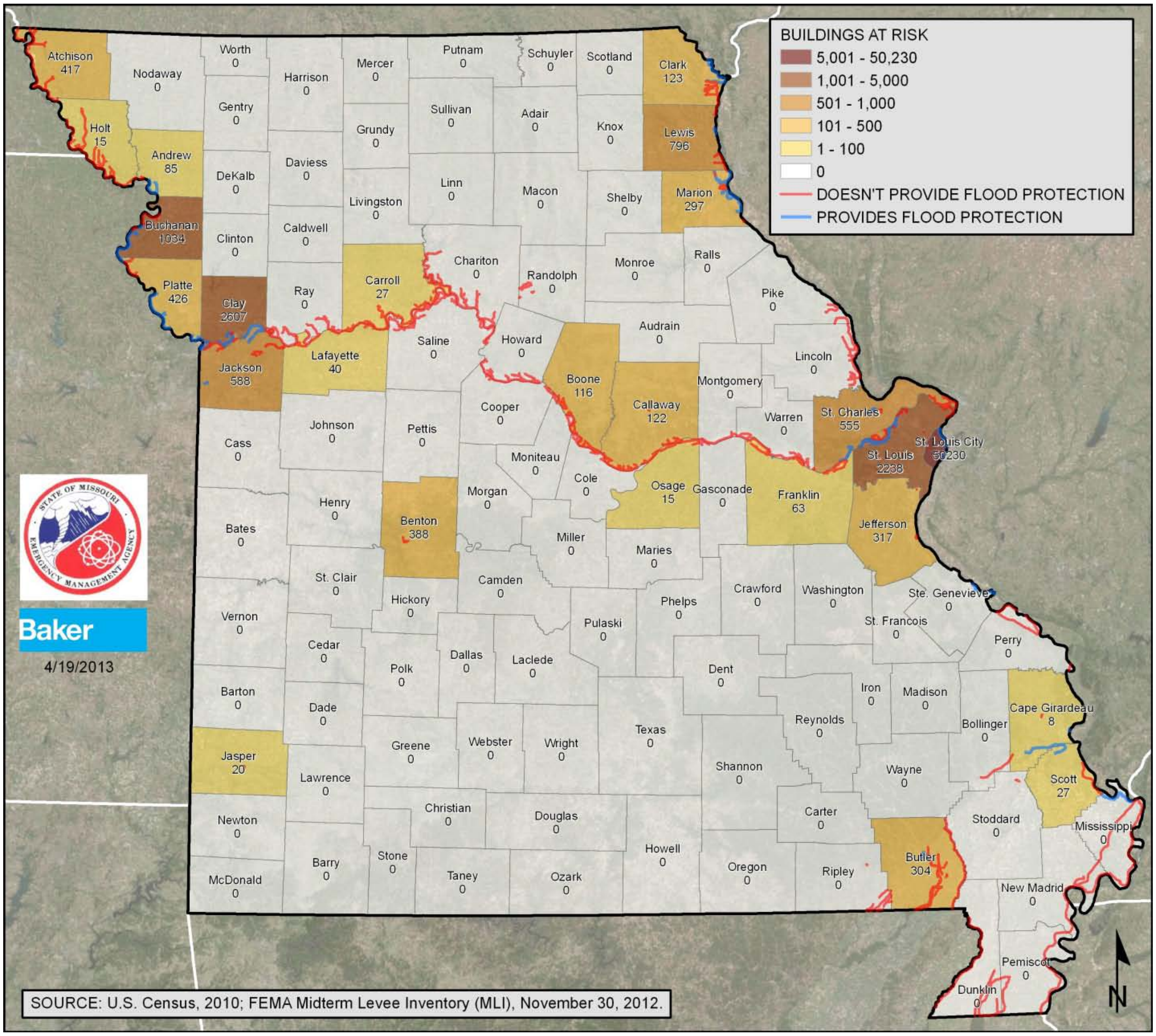


Figure 3.5.3.3 - Residential Building Exposure: Missouri Levees in USACE Levee Safety Program Providing 100-year or Greater Flood Protection



Overview and Analysis of Potential Loss Estimates to Levee Failure

Utilizing depth-damage percentage of 50 percent, the building loss estimate for failure of levee segments designed to provide 100-year flood protection is computed to be $5,165,390,702. A detailed breakdown by county is shown in Table 3.5.3b.

Table 3.5.3b Building Loss from Levee Failure by County

County	Building Loss Estimate
Clark	$8,719,488
Atchison	$33,991,210
Holt	$1,247,870
Lewis	$58,879,111
Andrew	$7,865,827
Marion	$24,309,551
Buchanan	$93,887,721
Carroll	$2,321,809
Platte	$49,033,280
Clay	$283,266,447
Lafayette	$3,808,987
Boone	$10,957,698
Jackson	$56,550,880
Callaway	$10,235,454
St. Charles	$63,094,949
St. Louis	$252,134,567
St. Louis City	$3,940,492,907
Franklin	$5,817,014
Osage	$1,325,948
Benton	$28,172,824
Jefferson	$31,426,310
Cape Girardeau	$685,019
Jasper	$1,612,807
Scott	$2,120,914
Butler	$193,432,111
Total	$5,165,390,702

3.5.4 Earthquake

For hazard profile information for earthquake, see Section 3.3.4.

Overview and Analysis of Vulnerability to Earthquakes

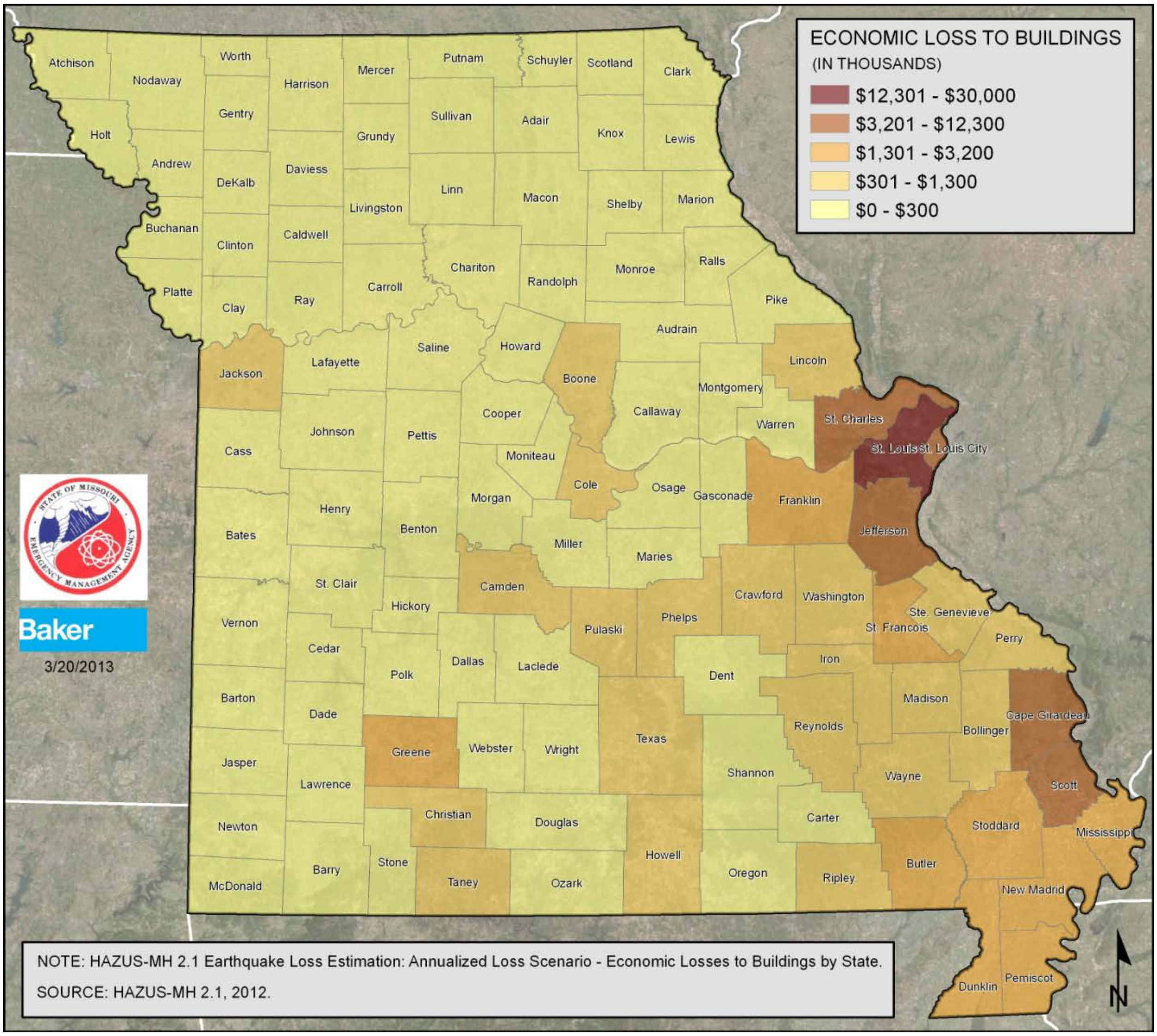
Hazus 2.1 was used to analyze vulnerability and estimate losses to earthquakes. All Hazus analyses were run using an enhanced, Level 2 inventory database comprised of updated demographic and aggregated data based on the 2010 census. Additionally, site-specific essential facility data was updated based on 2011 HSIP inventory data. An annualized loss scenario that enabled an "apples to apples" comparison of earthquake risk for each county was run. A second scenario, based on an event with a 2% probability of exceedance in 50 years, was done to model a worst case earthquake using a level of ground shaking recognized in earthquake-resistant design.

The Central United States Earthquake Consortium provided state-wide National Earthquake Hazards Reduction Program (NEHRP) site classification and soil liquefaction characteristics. Furthermore, the Missouri Department of Natural Resources provided more detailed, quad-based NEHRP site classification and soil liquefaction characteristics for the areas surrounding the City of St. Louis. These data sets were used as additional, Level 2 data inputs to enhance the accuracy of earthquake hazard modeling. It should be noted that some of the National Earthquake Hazard Reduction Program (NEHRP) site classification attributes were slightly altered for incorporation into the Hazus platform. Areas that were classified as "C to D" were re-attributed as "D" since in these instances Hazus does not allow the data in its original format.

Annualized Loss Scenario

The results of the updated annualized loss scenario are shown in Figure 3.5.4.1 and Table 3.5.4a. The map in Figure 3.5.4.3 shows economic losses to buildings annualized over eight earthquake return periods (100, 200, 500, 750, 1,000, 1,500, 2,000, and 2,500 years). Hazus defines annualized loss as the expected value of loss in any one year. The software develops annualized loss estimates by aggregating the losses and their exceedance probabilities from the eight return periods. Annualized loss is the maximum potential annual dollar loss resulting from various return periods averaged on a 'per year' basis. It is the summation of all Hazus-supplied return periods multiplied by the return period probability (as a weighted calculation). This is the scenario that FEMA uses to compare relative risk from earthquakes and other hazards at the county level nationwide. The trend shows dollar losses to be most significant in the southeastern portion of the State and in the urbanized areas near St. Louis. This is consistent with the southeastern portion of the State's proximity to the New Madrid Seismic Zone and the fact that the more developed areas in the region are likely to suffer the most building losses, particularly where there are large numbers of unreinforced masonry buildings.

Figure 3.5.4.1 - Hazus Earthquake Loss Estimation: Annualized Loss Scenario—Total Economic Losses to Buildings



The total annualized expected losses (including building and income losses) are presented in Table 3.5.4a on the next page and ranked from highest total losses to lowest. Included in the table are the annualized loss ratio and a ranking based on this loss ratio. The loss-ratio column in Table 3.5.4a represents the ratio of the average annualized losses divided by the entire building inventory by county as calculated by Hazus. The loss ratio is an indication of the economic impacts an earthquake could have, and how difficult it could be for a particular community to recover from an event. The top 10 counties in terms of the highest annualized loss ratio are highlighted. The table indicates that the highest risk is to the counties closest to the New Madrid Seismic Zone, which are likely to have considerable portions of the building inventory damaged during an earthquake.

Table 3.5.4a Hazus Earthquake Loss Estimation: Annualized Loss Scenario

	Building Loss Total ($)*	Loss Ratio %**	Income Loss Total ($)*	Total Economic Loss to Buildings ($)*	Loss Ratio Rank
St. Louis	23960	0.01	5788	29748	29
St. Louis City	9613	0.02	2742	12355	20
Cape Girardeau	5738	0.06	1372	7110	7
St. Charles	4932	0.01	1111	6043	30
Jefferson	4626	0.02	897	5523	23
Scott	4249	0.09	847	5096	4
Dunklin	2596	0.08	597	3193	5
New Madrid	2448	0.12	442	2890	2
Stoddard	2441	0.07	467	2908	6
Pemiscot	2295	0.13	484	2779	1
Butler	2194	0.05	630	2824	8
St. Francois	2161	0.03	517	2678	13
Mississippi	1601	0.12	276	1877	3
Franklin	1461	0.01	351	1812	39
Greene	1355	0.00	501	1856	87
Perry	1063	0.04	208	1271	9
Jackson	776	0.00	219	995	80
Ste. Genevieve	735	0.03	145	880	12
Howell	723	0.02	212	935	24
Boone	611	0.00	235	846	107
Phelps	520	0.01	174	694	32
Wayne	503	0.03	100	603	11
Cole	480	0.00	186	666	94
Ripley	463	0.03	106	569	14
Bollinger	455	0.04	83	538	10
Madison	448	0.03	109	557	16
Washington	423	0.02	97	520	19
Iron	349	0.03	80	429	17
Lincoln	333	0.01	79	412	36
Pulaski	332	0.01	87	419	31
Crawford	325	0.01	84	409	42
Taney	313	0.01	150	463	28
Christian	302	0.00	81	383	98
Camden	283	0.00	86	369	103
Texas	273	0.01	77	350	27
Reynolds	269	0.03	78	347	15

	Building Loss Total ($)*	Loss Ratio %**	Income Loss Total ($)*	Total Economic Loss to Buildings ($)*	Loss Ratio Rank
Warren	254	0.01	58	312	26
Oregon	247	0.02	59	306	22
Dent	240	0.01	62	302	41
Carter	209	0.03	47	256	18
Clay	208	0.00	53	261	96
Jasper	203	0.00	72	275	79
Callaway	201	0.00	72	273	104
Laclede	193	0.01	63	256	37
Shannon	178	0.02	37	215	21
Webster	156	0.00	41	197	44
Gasconade	152	0.01	42	194	38
Stone	150	0.00	43	193	47
Wright	145	0.01	41	186	25
Barry	111	0.00	35	146	111
Newton	108	0.00	41	149	62
Miller	106	0.00	30	136	67
Lawrence	103	0.00	34	137	75
Cass	99	0.00	21	120	101
Osage	96	0.01	23	119	34
Pettis	95	0.00	30	125	60
Ozark	92	0.01	25	117	33
Douglas	90	0.01	23	113	40
Audrain	89	0.00	28	117	112
Polk	87	0.00	27	114	57
Pike	81	0.00	27	108	59
Morgan	80	0.00	23	103	63
Montgomery	78	0.00	22	100	64
Platte	78	0.00	18	96	58
Marion	76	0.00	29	105	70
Johnson	75	0.00	22	97	78
Maries	65	0.01	14	79	35
Buchanan	63	0.00	19	82	106
Dallas	53	0.00	13	66	91
Benton	52	0.00	12	64	108
Randolph	49	0.00	17	66	54
Cooper	43	0.00	13	56	93
Henry	43	0.00	14	57	84
Moniteau	43	0.00	11	54	66

	Building Loss Total ($)*	Loss Ratio %**	Income Loss Total ($)*	Total Economic Loss to Buildings ($)*	Loss Ratio Rank
Lafayette	40	0.00	10	50	76
Vernon	37	0.00	18	55	45
Saline	36	0.00	12	48	52
McDonald	33	0.00	9	42	69
Ralls	33	0.00	7	40	55
Cedar	29	0.00	11	40	100
Hickory	26	0.00	6	32	83
Adair	24	0.00	9	33	115
Barton	23	0.00	7	30	110
Howard	22	0.00	7	29	81
Monroe	22	0.00	6	28	65
Bates	20	0.00	5	25	109
Macon	20	0.00	6	26	71
Ray	20	0.00	4	24	53
St. Clair	20	0.00	7	27	48
Dade	17	0.00	6	23	92
Lewis	17	0.00	6	23	74
Clinton	14	0.00	4	18	95
Shelby	13	0.00	5	18	49
Carroll	12	0.00	4	16	102
Linn	12	0.00	5	17	73
Chariton	11	0.00	4	15	99
Livingston	11	0.00	5	16	72
Nodaway	11	0.00	4	15	61
Andrew	8	0.00	1	9	114
Caldwell	7	0.00	1	8	105
Clark	7	0.00	1	8	97
Grundy	7	0.00	1	8	86
Daviess	5	0.00	1	6	90
DeKalb	5	0.00	1	6	89
Harrison	5	0.00	1	6	85
Knox	5	0.00	1	6	77
Scotland	5	0.00	1	6	50
Atchison	4	0.00	1	5	113
Holt	4	0.00	0	4	82
Sullivan	4	0.00	1	5	46
Gentry	3	0.00	1	4	88
Putnam	3	0.00	1	4	56

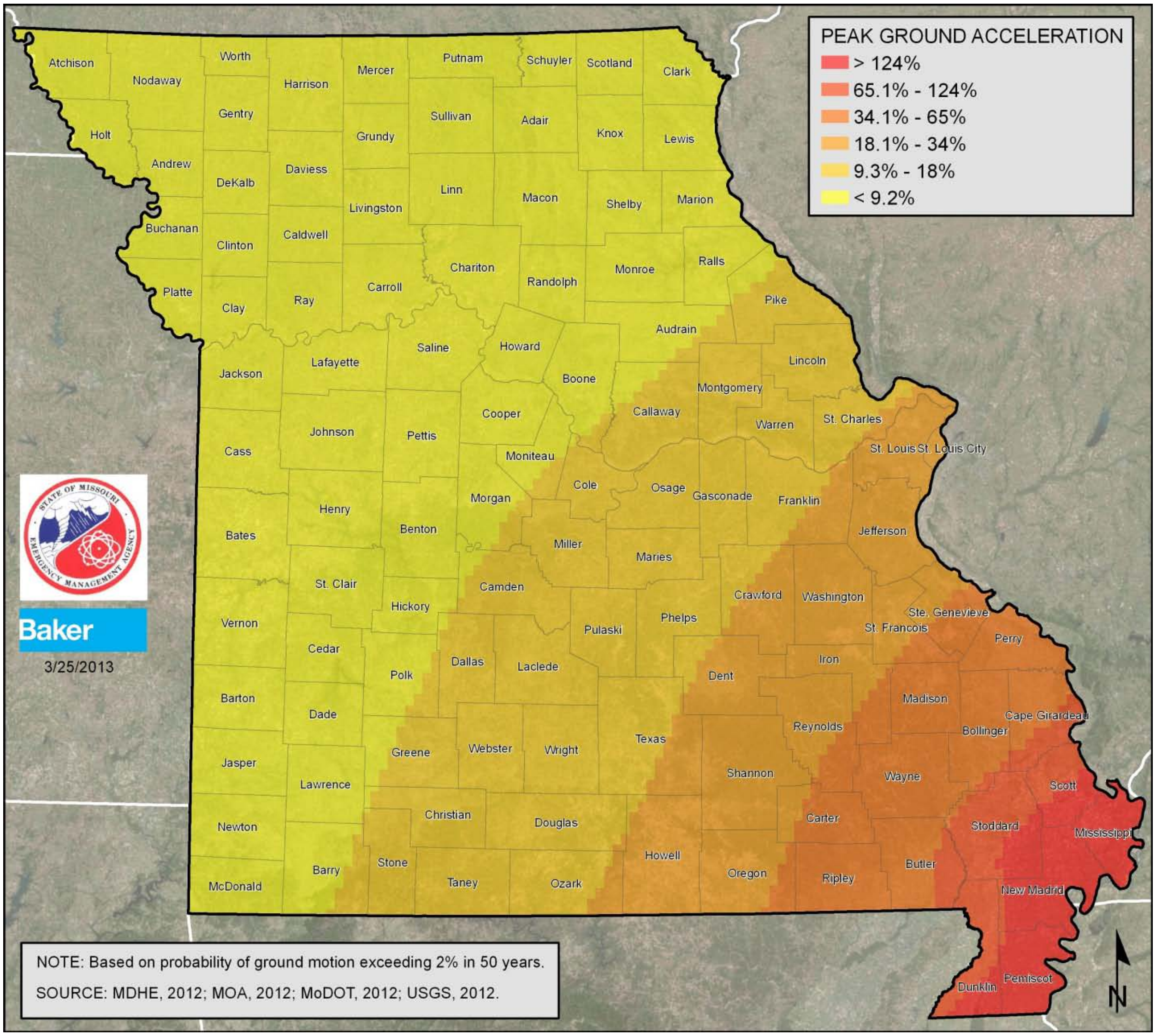
	Building Loss Total ($)*	Loss Ratio %**	Income Loss Total ($)*	Total Economic Loss to Buildings ($)*	Loss Ratio Rank
Schuyler	3	0.00	0	3	51
Mercer	1	0.00	0	1	68
Worth	1	0.00	0	1	43

Source: Hazus 2.1
*All $ values are in thousands
**Loss ratio is the sum of structural and nonstructural damage divided by the entire building inventory value within a county
***Note: Total loss numbers provide an estimate of total losses and due to rounding, these numbers may differ slightly from the glob al summary report outputs from HAZUS

2% Probability of Exceedance in 50 Years Earthquake Scenario

A second scenario, based on an event with a 2% probability of exceedance in 50 years, was done to model a worst case scenario. The methodology is based on probabilistic seismic hazard shaking grids developed by the U.S. Geological Survey (USGS) for the National Seismic Hazard Maps that are included with Hazus. The USGS maps provide estimates of peak ground acceleration and spectral acceleration at periods of 0.3 second and 1.0 second, respectively, which have a 2% probability of exceedance in the next 50 years. The International Building Code uses this level of ground shaking for building design in seismic areas. This scenario used a 7.7 driving magnitude in HAZUS-MH, which is the magnitude used for typical New Madrid fault planning scenarios in Missouri. While the 2% probability of exceedance in the next 50 years ground motion maps incorporate the shaking potential from all faults with earthquake potential in and around Missouri, the most severe shaking is predominately generated by the New Madrid Fault. This pattern of shaking can be seen in Figure 3.5.4.2, with corresponding potential for damage.

Figure 3.5.4.2 - Hazus Earthquake 2% Probability of Exceedance in 50 Years —Ground Shaking Potential



Scenario Results

The results of this probabilistic scenario include total losses exceeding $65 billion in building and income losses, with overall economic losses exceeding $77 billion. Over 20 percent (%) of the total number of buildings in the State would be at least moderately damaged. 19 percent (%) of the building and income losses would be related to business interruption. Figure 3.5.4.3 summarizes the results from the Hazus run for the entire state (Hazus Earthquake Event Summary Report). Table 3.5.4b summarizes the building related losses by county. Hazus estimates direct damage to structural and non-structural building components separately. Structural components are the walls, columns, beams and flood systems that are responsible for holding up the building. In other words, the structural components are the gravity and lateral load resisting systems. Non-structural building components include building mechanical/electrical systems and architectural components such as partition walls, ceilings, windows and exterior cladding that are not designed as part of the building load carrying system. Equipment that is not an integral part of the building, such as computers, is considered building contents.

Damage to structural components affects other losses differently than damage to non-structural components. For example, if the ceiling tiles fall down in a building, business operations can probably resume once the debris is removed. On the other hand, if a column in a building is damaged, there is a life safety hazard until the column is repaired or temporarily shored, possibly resulting in a long-term disruption.

Figure 3.5.4.3 depicts a map of the modeled earthquake impacts by county based on building losses, including structural and nonstructural damage, content and inventory loss, and wage and income loss. Table 3.5.4c depicts loss ratio by county, which is the ratio of the building structure and nonstructural damage to the value of the entire building inventory. The loss ratio is a measure of the disaster impact to community sustainability, which is generally considered at risk when losses exceed 10 percent of the built environment (FEMA). The loss-ratio map depicts considerable losses in southeastern Missouri, which is consistent with this area's close proximity to the New Madrid Seismic Zone and high liquefaction potential.

Limitations to the Hazus loss modeling include inability to accurately assess the impact to long-span bridges, such as those crossing the Mississippi River. Damage to major infrastructure, such as power and other utility distribution systems, is estimated based on a proxy of the population within the study area and not on actual data representing these systems.

Improvements to future Hazus software versions and data sets may include using more extensive geologic mapping (as it becomes available), using more extensive ground shaking mapping, adding utilities infrastructure, and adding groundwater depth maps to the analysis. More extensive geologic and ground shaking mapping north of St. Louis would enable more accurate representation of the earthquake hazard in northeastern Missouri.

Table 3.5.4b Hazus Earthquake Loss Estimation 2% Probability of Exceedance in 50 Years Scenario Results Summary of Overall Impacts in Missouri

Type of Impact	Impacts to Region
Total Buildings Damaged	Slight: 577,028 Moderate: 362,954 Extensive: 133,420 Complete: 71,801
Total Economic Loss to Buildings (includes building and income related Losses)	$65.5 billion
Total Economic Losses (includes building, income and lifeline losses)	$77.9 billion
Casualties (based on 2 a.m. time of occurrence)	Without requiring hospitalization: 20,286 Requiring hospitalization: 5,045 Life threatening: 662 Fatalities: 1,278
Casualties (based on 2 p.m. time of occurrence)	Without requiring hospitalization: 34,271 Requiring hospitalization: 9,153 Life threatening: 1,378 Fatalities: 2,608

Type of Impact	Impacts to Region
Casualties (based on 5 p.m. time of occurrence)	Without requiring hospitalization: 21,094 Requiring hospitalization: 5,827 Life threatening: 1,495 Fatalities: 1,600
Damage to Schools	1,202 with at least moderate damage
Damage to Hospitals	67 with at least moderate damage
Damage to Transportation Systems	1,793 highway bridges, at least moderate damage 745 highway bridges, complete damage 4 railroad bridges, moderate damage 12 airport facilities, moderate damage
Households without Power/Water Service (based on 2,194,594 households)	Power loss, Day 1: 381,342 Water loss, Day 1: 212,652 Water loss, Day 3: 146,048 Water loss, Day 7: 90,645 Water loss, Day 30: 45,905 Water loss, Day 90: 13,667
Displaced Households	63,057
Shelter Requirements	41,553 people out of 5,988,927 total population in region
Debris Generation	24.9 million tons

Source: Hazus 2.1

Figure 3.5.4.3 - Hazus Earthquake Loss Estimation with a 2% Probability of Exceedance in 50 Years Scenario—Total Economic Loss To Buildings

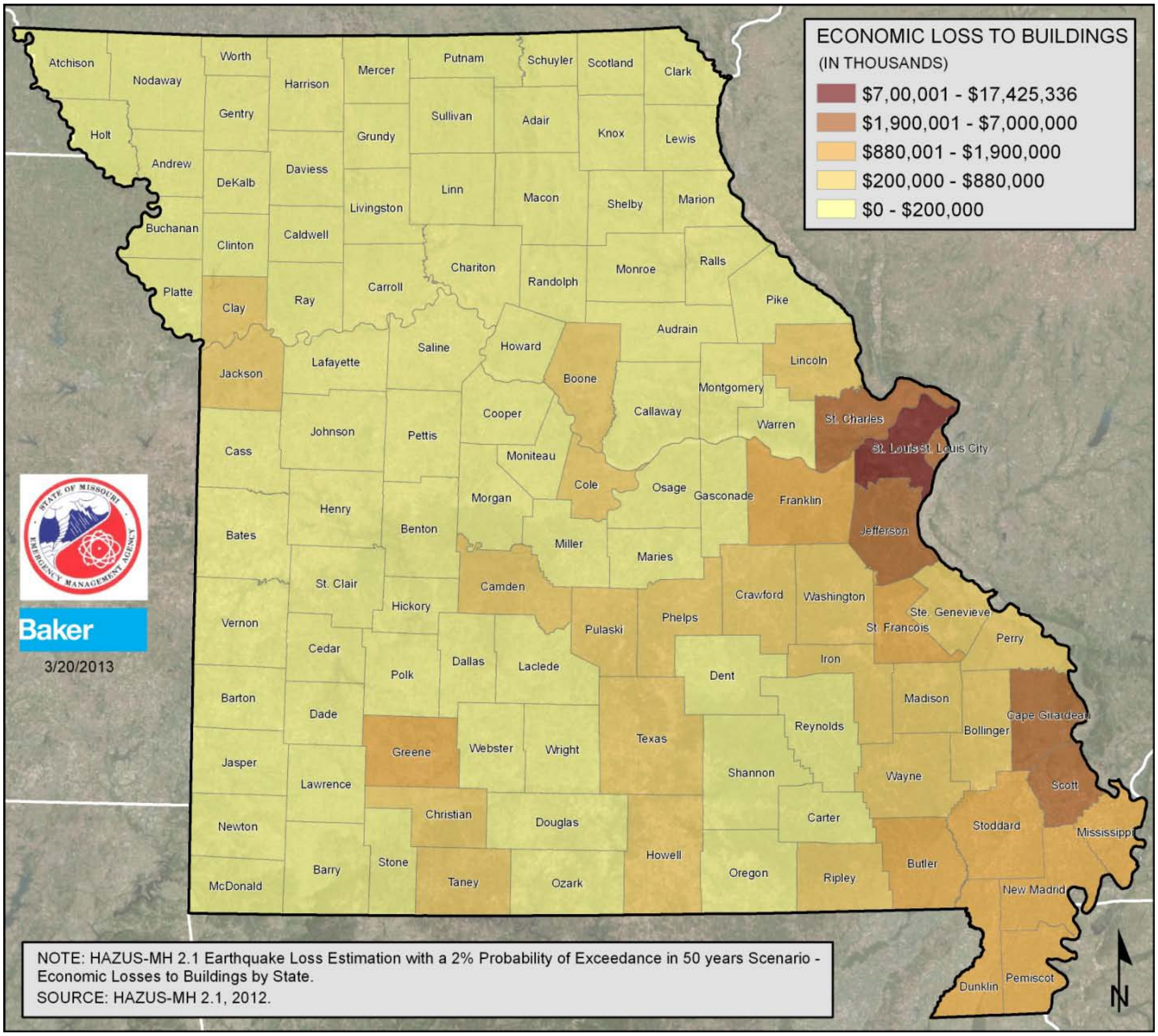


Figure 3.5.4.5 - Hazus Earthquake Loss Estimation with a 2% Probability of Exceedance in 50 Years Scenario—Loss Ratio

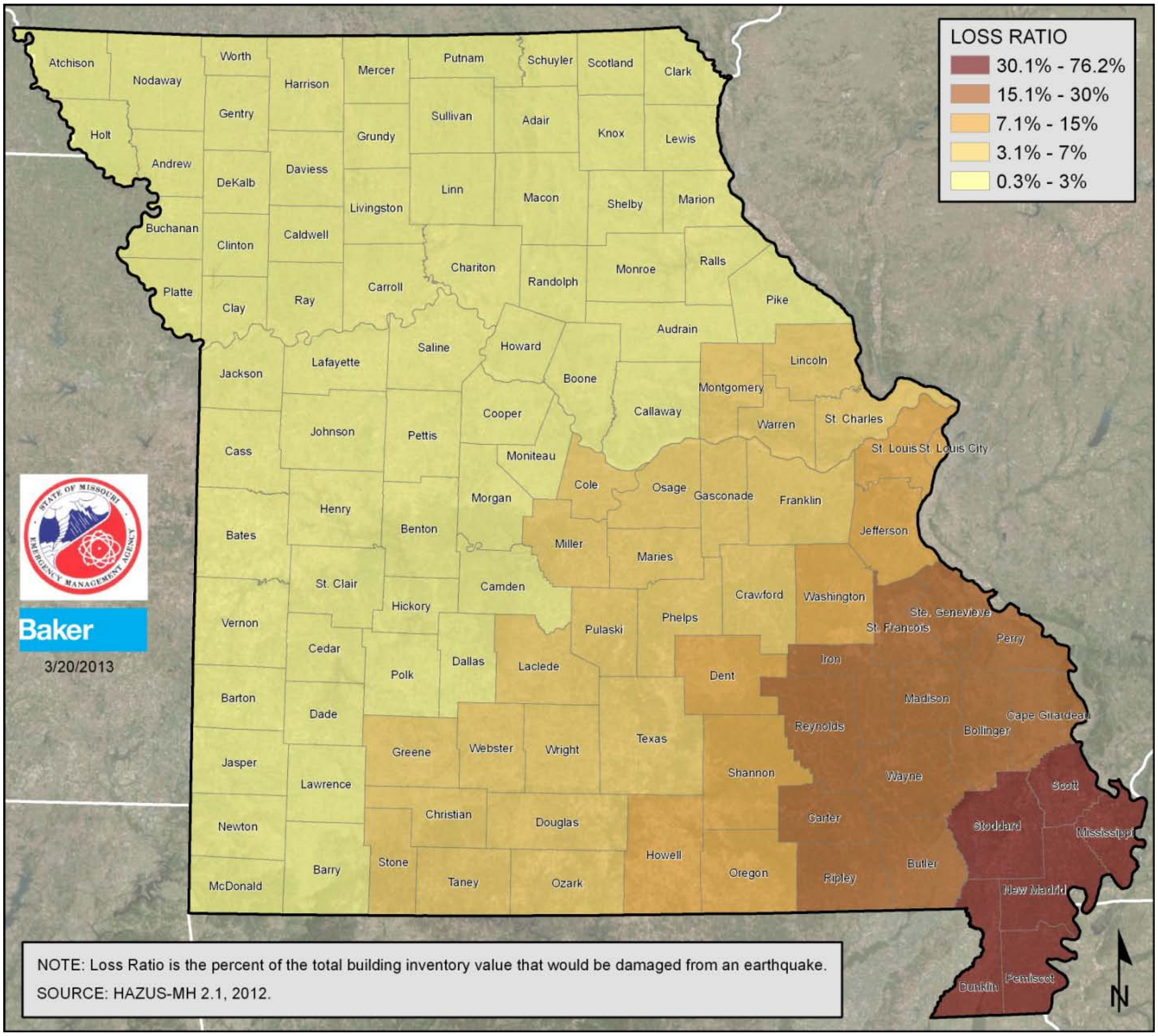


Table 3.5.4c ranks the counties by the total building losses. The loss ratio is included and the top 10 counties ranked by loss ratio are highlighted.

Table 3.5.4c HAZUS-MH Earthquake Loss Estimation: 2% Probability of Exceedance in 50 Years Scenario Results Building Impacts by County, Ranked by Highest Building Losses

County	Structural Damage ($)*	Non-Structural Damage ($)*	Contents Damage and Inventory Loss ($)*	Loss Ratio (%)**	Income Loss ($)*	Total Economic Loss to Buildings ($)*,***	Loss Ratio Rank
St. Louis	2563466	8323791	3088770	8.54	3449309	17425336	26
St. Louis City	961452	3266716	1288956	10.21	1609599	7126723	24
Cape Girardeau	537316	2002412	757082	31.92	744505	4041315	7
St. Charles	573527	1866226	649186	6.23	695400	3784339	32
Jefferson	494116	1600916	534483	10.21	520387	3149902	23
Scott	437177	1570717	551276	55.21	462950	3022120	4
Dunklin	280842	963581	325083	49.92	329843	1899349	5
Stoddard	263232	919758	305105	45.69	263730	1751825	6
New Madrid	259079	911720	287952	74.58	246663	1705414	2
Butler	222353	781152	297008	27.25	357591	1658104	8
Pemiscot	234091	857572	283720	76.15	262226	1637609	1
St. Francois	233482	771898	270467	16.55	304619	1580466	18
Greene	192009	603517	224345	2.85	335805	1355676	49
Franklin	176519	537722	199063	6.95	221142	1134446	28
Mississippi	175394	603919	179448	73.06	153274	1112035	3
Jackson	139943	427463	144419	0.68	174461	886286	92
Perry	118022	377416	139927	23.32	120677	756042	9
Howell	85830	264815	94510	10.29	132809	577964	22
Boone	73438	258341	98964	1.91	138339	569082	58
Ste. Genevieve	78864	252982	89005	16.87	81993	502844	17
Cole	67074	208325	74987	3.02	122536	472922	45
Phelps	63722	205571	72687	6.29	114888	456868	31
Wayne	58508	192620	58908	21.25	59762	369798	12
Ripley	52584	173010	59860	21.48	63372	348826	11
Taney	44073	142084	46807	3.95	104882	337846	40
Madison	49464	162301	58732	19.41	64315	334812	13
Washington	49090	156018	46886	12.22	58654	310648	20
Christian	46382	142958	48236	2.98	57196	294772	46
Camden	40470	137621	44936	2.50	59870	282897	53
Pulaski	44123	134547	41864	4.76	56906	277440	35
Bollinger	51309	168604	50491	23.09	4730	275134	10

County	Structural Damage ($)*	Non-Structural Damage ($)*	Contents Damage and Inventory Loss ($)*	Loss Ratio (%)**	Income Loss ($)*	Total Economic Loss to Buildings ($)*,***	Loss Ratio Rank
Lincoln	44630	132924	45359	4.09	50314	273227	39
Crawford	40328	121360	41936	7.46	53115	256739	27
Iron	38767	126345	42917	17.18	47215	255244	16
Clay	40171	118189	37672	0.63	43229	239261	96
Texas	36250	106379	36529	6.92	51531	230689	29
Jasper	32303	96853	33692	1.19	48323	211171	76
Reynolds	28874	97764	36215	17.65	47169	210022	15
Warren	32684	99986	35180	4.27	37124	204974	37
Callaway	27619	85694	30946	2.74	45339	189598	50
Oregon	30093	93317	28653	14.64	36415	188478	19
Dent	29514	88659	30144	8.55	38351	186668	25
Laclede	28940	82834	29771	3.86	43583	185128	41
Carter	24032	78826	25250	19.40	28189	156297	14
Stone	23447	73992	23125	2.89	30318	150882	47
Webster	23842	70872	23840	3.60	29048	147602	43
Shannon	20896	66487	20625	12.04	22382	130390	21
Gasconade	20332	59605	21311	4.70	26912	128160	36
Wright	20380	58519	20167	5.30	27475	126541	33
Newton	16964	49616	17417	1.32	27169	111166	72
Barry	16091	47971	18229	2.03	21992	104283	55
Cass	18117	53639	16034	0.70	15836	103626	90
Miller	15772	47395	15953	2.88	21477	100597	48
Lawrence	15261	45454	16372	1.83	20657	97744	60
Pettis	14737	43231	15727	1.34	19734	93429	71
Platte	15151	46173	13993	0.60	15157	90474	98
Osage	13465	40069	15234	3.75	15511	84279	42
Polk	12612	38574	13661	2.04	17841	82688	54
Buchanan	12914	37991	13044	0.52	16883	80832	103
Audrain	12447	36395	13446	2.00	16924	79212	56
Ozark	12376	37370	12060	6.34	16515	78321	30
Douglas	12400	37506	12276	4.85	14901	77083	34
Johnson	11500	37010	12858	0.96	14593	75961	82
Morgan	12170	36535	12021	1.93	14536	75262	57
Pike	11939	34560	12181	2.68	16520	75200	51
Marion	10868	33599	11627	1.59	16955	73049	63

County	Structural Damage ($)*	Non-Structural Damage ($)*	Contents Damage and Inventory Loss ($)*	Loss Ratio (%)**	Income Loss ($)*	Total Economic Loss to Buildings ($)*,***	Loss Ratio Rank
Montgomery	11721	31627	11668	3.46	14505	69521	44
Maries	8804	26127	9213	4.10	9479	53623	38
Dallas	8428	25109	8200	2.59	9746	51483	52
Benton	8283	25322	7639	1.50	9144	50388	66
Randolph	7326	22498	8044	1.28	11068	48936	74
Henry	7180	20741	7396	1.17	9421	44738	77
Vernon	5823	17863	6927	1.01	11832	42445	81
Cooper	6754	19413	6782	1.54	8889	41838	65
Lafayette	6964	19847	6382	0.76	7441	40634	88
Moniteau	6251	18764	6803	1.90	7129	38947	59
Saline	5966	18125	6204	1.04	8022	38317	80
McDonald	5234	15693	4845	1.40	6261	32033	68
Cedar	4631	13777	4806	1.34	7058	30272	70
Adair	3916	12863	4499	0.68	7142	28420	91
Ralls	4704	13595	4877	1.77	4938	28114	62
Hickory	3991	12031	3560	1.78	4408	23990	61
Barton	3871	10894	3998	1.13	4885	23648	78
Ray	3950	11217	3288	0.64	3694	22149	95
Howard	3508	10464	3614	1.38	4406	21992	69
Monroe	3492	10059	3326	1.50	4226	21103	67
Macon	3386	9684	3086	0.90	4642	20798	83
St. Clair	3183	9384	3052	1.32	4334	19953	73
Bates	3362	9724	3093	0.82	3647	19826	85
Dade	2837	8197	2799	1.55	3332	17165	64
Clinton	2983	8486	2475	0.53	2979	16923	102
Lewis	2575	7531	2524	1.12	3355	15985	79
Linn	2397	6511	2078	0.68	3226	14212	93
Nodaway	2081	6506	2331	0.41	3141	14059	112
Livingston	2233	6078	1981	0.60	3199	13491	97
Shelby	2181	5969	2107	1.20	2684	12941	75
Carroll	2042	5662	1914	0.72	2456	12074	89
Chariton	1960	5337	1697	0.89	2259	11253	84
Andrew	1969	5496	1547	0.47	1890	10902	109
Grundy	1352	3709	1178	0.49	1917	8156	105
Caldwell	1438	3917	1127	0.57	1409	7891	99

County	Structural Damage ($)*	Non-Structural Damage ($)*	Contents Damage and Inventory Loss ($)*	Loss Ratio (%)**	Income Loss ($)*	Total Economic Loss to Buildings ($)*,***	Loss Ratio Rank
Clark	1259	3528	1082	0.78	1534	7403	86
Daviess	1152	3100	945	0.49	1191	6388	104
DeKalb	1134	3131	876	0.48	1238	6379	108
Harrison	1032	2703	770	0.38	1326	5831	114
Scotland	855	2310	753	0.67	1213	5131	94
Sullivan	847	2320	739	0.56	1177	5083	101
Atchison	788	2210	755	0.46	1078	4831	110
Knox	828	2228	688	0.77	982	4726	87
Holt	773	2116	686	0.49	904	4479	106
Gentry	722	1886	580	0.40	917	4105	113
Putnam	656	1743	525	0.49	889	3813	107
Schuyler	571	1542	434	0.57	675	3222	100
Mercer	406	1083	277	0.41	406	2172	111
Worth	219	567	153	0.32	217	1156	115

Source: Hazus 2.1
*All $ values are in thousands
**Loss ratio is the sum of structural and nonstructural damage divided by the entire building inventory value within a county
***Total economic loss to buildings includes inventory loss, relocation loss, capital-related loss, wages loss, and rental income loss
****Note: Total loss numbers provide an estimate of total losses and due to rounding, these numbers may differ slightly from the glob al summary report outputs from HAZUS

Table 3.5.4e shows social impact estimates by county for the same event. Table 3.5.4d provides definitions for casualty severity, displaced households, and short-term shelter needs as used in Table 3.5.4e. Casualties resulting from an earthquake will vary depending on if the earthquake occurs during the middle of the night, middle of the day, or rush hour. Hazus provides casualty estimates for three different times of day: 2 a.m., 2 p.m., and 5 p.m. Table 3.5.4e represents the 2 a.m. timeframe. This scenario models the earthquake at 2am, when Missouri residents are in their homes and not at their workplace. During any given day or week, people spend more time in their homes than they do in their workplace; this scenario produces the most accurate social impact analysis.

The MMI Zone is the Modified Mercalli Intensity Zone classification determined according to Peak-Ground Acceleration (PGA). The MMI zones I-XII indicate potential damage classifications which range from none to very heavy. Additional details on each MMI Zone are included in Section 3.7.4.

Table 3.5.4d Casualty Severity, Displaced Households, and Short-Term Shelter Needs

Casualty Severity Level 1	Injuries will require medical attention but hospitalization is not needed.
Casualty Severity Level 2	Injuries will require hospitalization but are not considered life-threatening

Casualty Severity Level 3	Injuries will require hospitalization and can become life threatening if not promptly treated.
Casualty Severity Level 4	Victims are killed by the earthquake.
Displaced Households	The number of households that are expected to be displaced from their homes due to the earthquake
Short-Term Shelter Needs	The number of displaced people that will require accommodations in temporary public shelters.

Source: Hazus 2.1

Table 3.5.4e Social Impact Estimates by County from the 2% Probability of Exceedance in 50 Years Scenario 2 a.m. time of occurrence

County	MMI Zone	Level1	Level2	Level3	level4	Total	Displaced Households	Short-Term Shelter Needs
Adair	V	6	1	0	0	7	12	12
Andrew	V	3	0	0	0	3	3	2
Atchison	V	1	0	0	0	1	1	1
Audrain	VI	19	3	0	1	23	22	15
Barry	VI	27	4	0	1	32	32	21
Barton	VI	5	1	0	0	6	5	3
Bates	VI	5	1	0	0	6	5	3
Benton	VI	10	2	0	0	12	12	7
Bollinger	VIII	194	53	7	14	268	493	333
Boone	VI	88	14	1	3	106	243	175
Buchanan	V	16	2	0	0	18	24	15
Butler	VIII	727	202	29	56	1014	2153	1421
Caldwell	V	2	0	0	0	2	2	1
Callaway	VI	41	7	1	1	50	61	40
Camden	VI	40	7	1	1	49	76	40
Cape Girardeau	IX	1419	404	60	117	2000	4736	2952
Carroll	V	3	0	0	0	3	3	2
Carter	VIII	74	19	3	5	101	184	127
Cass	V	21	3	0	0	24	27	15
Cedar	VI	7	1	0	0	8	8	5
Chariton	VI	3	0	0	0	3	3	2
Christian	VI	60	11	1	2	74	136	79
Clark	V	2	0	0	0	2	2	2
Clay	V	41	6	1	1	49	79	43

County	MMI Zone	Level1	Level2	Level3	level4	Total	Displaced Households	Short-Term Shelter Needs
Clinton	V	4	0	0	0	4	5	3
Cole	VI	73	13	1	3	90	168	99
Cooper	VI	9	1	0	0	10	13	9
Crawford	VII	77	16	2	4	99	154	99
Dade	VI	4	1	0	0	5	6	4
Dallas	VI	16	3	0	0	19	18	12
Daviess	V	1	0	0	0	1	1	1
DeKalb	V	2	0	0	0	2	3	2
Dent	VII	60	13	2	3	78	114	73
Douglas	VII	27	5	1	1	34	42	29
Dunklin	IX	1095	311	42	80	1528	3793	2736
Franklin	VII	274	57	7	13	351	585	346
Gasconade	VII	29	5	1	1	36	47	28
Gentry	V	1	0	0	0	1	1	1
Greene	VI	233	40	4	8	285	604	375
Grundy	V	2	0	0	0	2	2	2
Harrison	V	1	0	0	0	1	1	1
Henry	VI	9	1	0	0	10	13	8
Hickory	VI	7	1	0	0	8	7	4
Holt	V	1	0	0	0	1	1	1
Howard	VI	5	1	0	0	6	6	4
Howell	VII	177	40	5	9	231	388	255
Iron	VIII	106	27	4	7	144	252	170
Jackson	V	160	22	2	4	188	325	204
Jasper	VI	44	6	1	1	52	74	49
Jefferson	VII	990	228	29	56	1303	2247	1308
Johnson	VI	16	2	0	0	18	29	22
Knox	V	1	0	0	0	1	1	1
Laclede	VI	48	9	1	2	60	81	52
Lafayette	V	9	1	0	0	10	12	7
Lawrence	VI	23	4	0	1	28	34	22
Lewis	VI	4	1	0	0	5	5	3
Lincoln	VII	63	12	1	2	78	107	66
Linn	V	3	0	0	0	3	3	2
Livingston	V	3	0	0	0	3	4	3
Macon	VI	5	1	0	0	6	6	4

County	MMI Zone	Level1	Level2	Level3	level4	Total	Displaced Households	Short-Term Shelter Needs
Madison	VIII	142	37	5	10	194	367	241
Maries	VII	15	3	0	1	19	22	14
Marion	VI	16	2	0	0	18	30	19
McDonald	VI	11	2	0	0	13	13	9
Mercer	V	1	0	0	0	1	1	0
Miller	VI	27	5	0	1	33	41	26
Mississippi	X	715	206	26	49	996	2924	2416
Moniteau	VI	10	2	0	0	12	12	8
Monroe	VI	5	1	0	0	6	6	4
Montgomery	VI	16	3	0	1	20	22	14
Morgan	VI	14	2	0	0	16	16	10
New Madrid	X	1070	307	38	72	1487	4583	3187
Newton	VI	26	4	0	1	31	31	20
Nodaway	V	3	0	0	0	3	5	4
Oregon	VIII	88	22	3	5	118	211	149
Osage	VII	18	3	0	1	22	26	16
Ozark	VII	30	6	1	1	38	47	29
Pemiscot	X	1096	316	39	75	1526	4508	3400
Perry	VIII	255	69	10	20	354	675	400
Pettis	VI	18	3	0	0	21	30	20
Phelps	VII	100	21	2	5	128	244	167
Pike	VI	18	3	0	1	22	24	16
Platte	V	16	2	0	0	18	41	21
Polk	VI	20	3	0	1	24	27	18
Pulaski	VII	83	17	2	4	106	143	145
Putnam	V	1	0	0	0	1	1	1
Ralls	VI	6	1	0	0	7	6	4
Randolph	VI	11	2	0	0	13	14	9
Ray	V	5	1	0	0	6	6	4
Reynolds	VIII	67	17	2	4	90	149	95
Ripley	VIII	192	51	7	14	264	489	337
Saline	VI	9	1	0	0	10	11	8
Schuyler	V	1	0	0	0	1	1	1
Scotland	V	1	0	0	0	1	1	1
Scott	X	1526	436	58	111	2131	5422	3667
Shannon	VII	59	14	2	3	78	120	83

County	MMI Zone	Level1	Level2	Level3	level4	Total	Displaced Households	Short-Term Shelter Needs
Shelby	VI	3	0	0	0	3	4	2
St. Charles	VII	742	157	20	39	958	2024	1082
St. Clair	VI	5	1	0	0	6	5	3
St. Francois	VIII	503	128	17	34	682	1388	965
St. Louis City	VII	1444	335	46	89	1914	6113	4286
St. Louis	VII	3733	846	113	221	4913	10700	6074
Ste. Genevieve	VIII	172	44	6	12	234	391	230
Stoddard	IX	912	259	35	68	1274	3246	2046
Stone	VI	36	6	1	1	44	56	32
Sullivan	V	2	0	0	0	2	2	1
Taney	VII	75	14	1	3	93	162	99
Texas	VII	70	14	2	3	89	133	95
Vernon	VI	7	1	0	0	8	10	7
Warren	VII	41	8	1	2	52	81	49
Washington	VII	155	35	4	8	202	279	204
Wayne	VIII	195	51	7	13	266	514	339
Webster	VII	43	8	1	2	54	62	43
Worth	V	0	0	0	0	0	0	0
Wright	VII	38	7	1	2	48	62	43
Total		**20,263**	**5,038**	**657**	**1,274**	**27,232**	**62,975**	**41,484**

3.5.5 Land Subsidence/Sinkholes

For hazard profile information for land subsidence/sinkholes, see Section 3.3.5.

Overview and Analysis of Vulnerability to Land Subsidence/Sinkholes

Sinkholes in Missouri are a common feature where limestone and dolomite outcrop. Dolomite is a rock similar to limestone with magnesium as an additional element along with the calcium normally present in the minerals that form the rocks. While some sinkholes may be considered a slow changing nuisance; other more sudden, catastrophic collapses can destroy property, delay construction projects, and contaminate ground water resources.

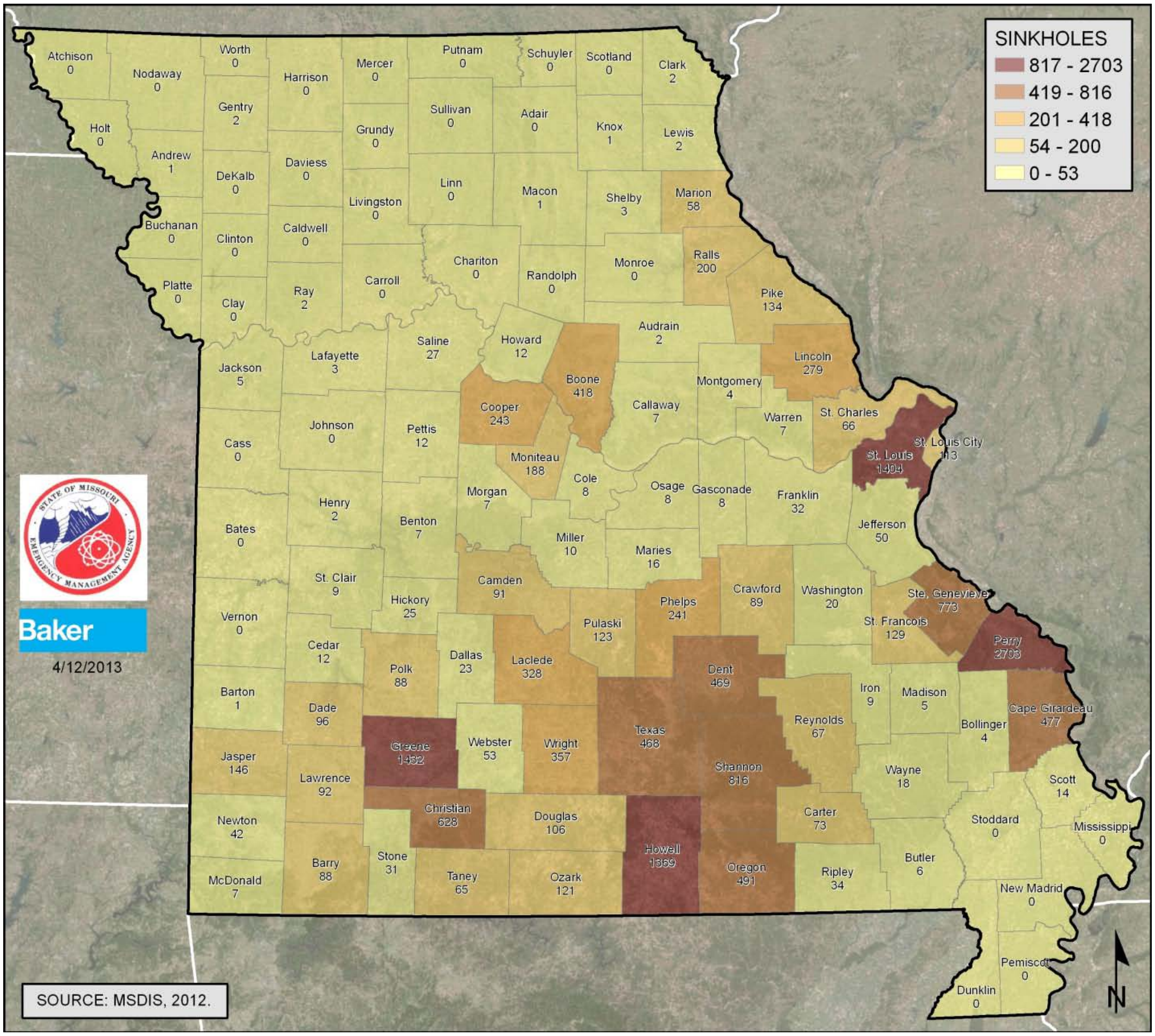
Sinkholes

The data from the Missouri Spatial Data Information Service website, http://msdis.missouri.edu/, shows the location of 15,574 sinkhole location map (Figure 3.5.5.1) for the entire state. The sinkhole inventory reports 2,703 in Perry County, 1,431 in Greene County, 1,404 in St. Louis County, and 1,369 in Howell County (UMC, 2011). These sinkholes can vary from a few feet to hundreds of acres and from less than one to more than 100 feet deep. They can also vary is shape like shallow bowls or saucers whereas other have vertical walls, some hold water and form natural ponds.

There are no statistics on the number of voids present in the subsurface that will collapse in the future to form new surface sinkholes, however, areas have been identified that have the greatest potential for future sinkholes and land subsidence.

Figure 3.5.5.1 - Sinkholes in Missouri

Source: Missouri Spatial Data Information Service, http://msdis.missouri.edu/



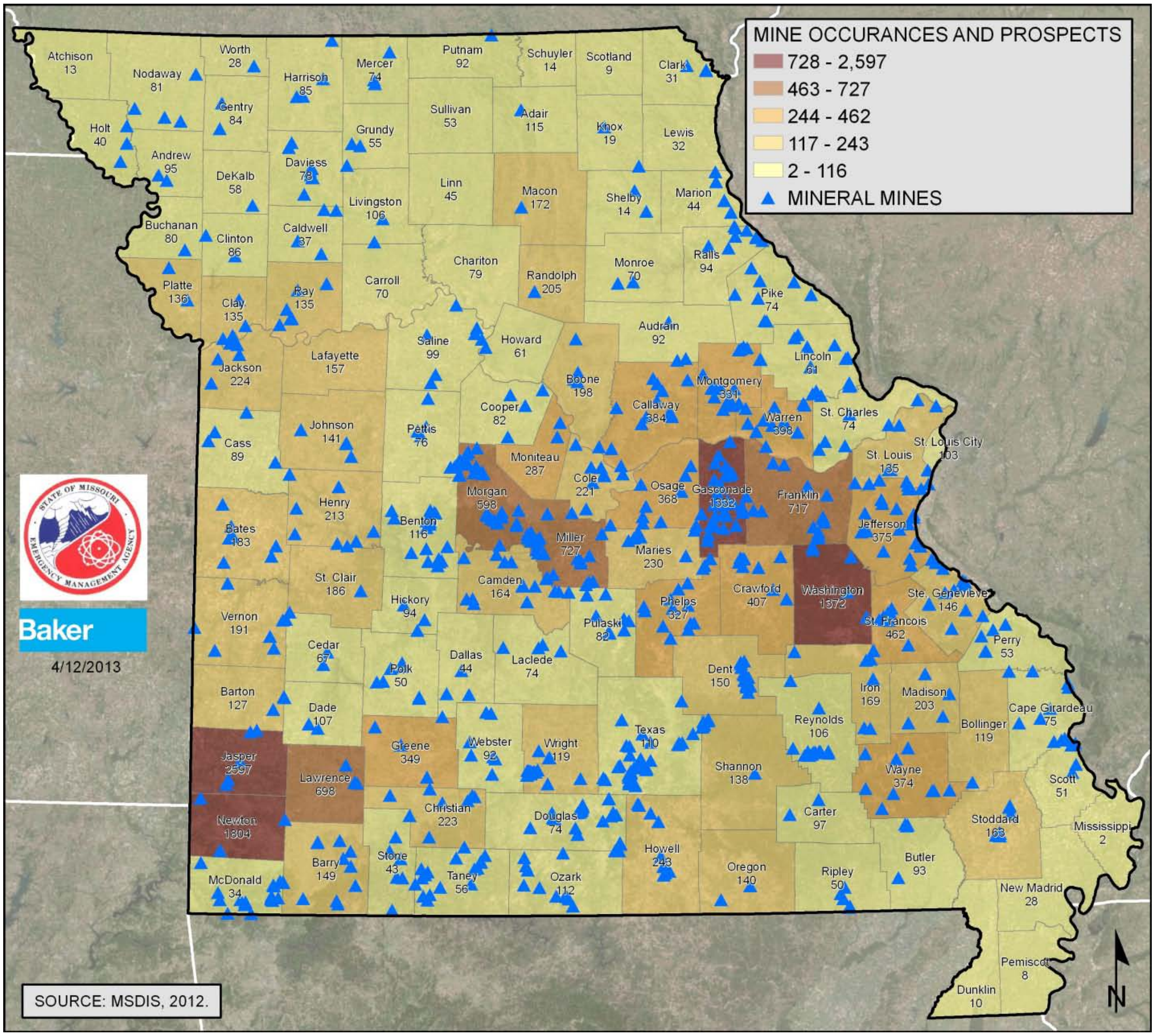
Caves

Missouri has more than 5,600 recorded caves, including 20 show caves, which are open to the public for guided tours (Missouri DNR, 2008). The data from the Missouri Spatial Data Information Service website, http://msdis.missouri.edu/, shows the location of caves but not a specific number by County.

Mines

The data from the Missouri Spatial Data Information Service website, http://msdis.missouri.edu/, shows the location of 23,342 mines in Missouri. The top five counties with mines are 2,596 in Jasper County, 1,805 in Newton County, 1,372 in Washington County, 1,332 in Gasconade County, and 727 in Miller County. Figure 3.5.5.2 gives a county by county summation of mines within each county's borders.

Figure 3.5.5.2 - Mines in Missouri



Overview and Analysis of Potential Loss Estimates to Land Subsidence/ Sinkholes

It is difficult to analysis the potential losses caused by land subsidence and sinkholes due to a lack of damage data associated with past events. The Missouri Department of Natural Resources, Division of Geology and Land Survey, records known events. Between 1970 and 2007, the Missouri Department of Natural Resources examined more than 160 collapses reported by the public. Most of these collapses were small with less than 10 feet in diameter and 10 feet deep, but some were large (Kaufmann, 2007). There are not cost estimates associated with these historical collapses. It is difficult to predict where sinkholes will become damaging to property and infrastructure.

Changes in Development for Jurisdictions in Hazard Prone Areas

Land Subsidence/sinkholes are common in Missouri. Catastrophic collapse sinkholes are rare compared to the bowl-shaped type sinkholes, but they are not uncommon. As more development occurs on

unmapped land subsidence area, vulnerability to this hazard will increase. Of the eleven Counties with the highest occurrence of sinkholes, three have seen a population increase of ten percent or more over the last decade. These include Christian, Greene, and Texas Counties with Christian County having the largest population increase at nearly 30 percent. The population of Lincoln County has increased by more than 25 percent since 2000 and has a moderate occurrence of sinkholes as illustrated in Figure 3.5.5.1. It is not known if development is occurring in hazard prone areas but it is recommended that this hazard be considered in local land use planning decisions. Of the local plans that were available for review and roll-up into the State plan, only three considered land subsidence/sinkholes in their hazard analysis. None of these specifically identified whether or not development is occurring on land prone to subsidence/sinkhole hazard (Missouri DNR, 2010).

3.5.6 Severe Thunderstorms (includes damaging winds, hail and lightning)

For hazard profile information for severe thunderstorms, see Section 3.3.6.

Overview and Analysis of Vulnerability to Severe Thunderstorms

Severe Thunderstorms are a common occurrence in Missouri. Since wind, hail, and lightning are all contributing elements of severe thunderstorms in Missouri, the planning team focused on damaging winds in excess of 67 miles per hour (58 knots), hail in excess of 0.75 inches or larger and damaging lightning strikes to analyze vulnerability, risk, and estimated losses to this hazard across the State of Missouri.

The method used to determine vulnerability to severe thunderstorms across Missouri was statistical analysis of data from several sources: National Climatic Data Center (NCDC) storm events data (1993 to December 31 2012), Crop Insurance Claims data from USDA's Risk Management Agency (2009-2012), U.S. Census Data (2010), USDA's Census of Agriculture (2007), and the calculated Social Vulnerability Index for Missouri Counties from the Hazards and Vulnerability Research Institute in the Department of Geography at the University of South Carolina.

Table 3.5.6a provides the housing density, building exposure, crop exposure, and social vulnerability data. These are the common data elements for the analysis of wind, hail, and lightning with one exception; the lightning analysis did not consider crop exposure as crop loss is an unlikely result of lightning events.

Table 3.5.6a Housing Density, Building Exposure and Crop Exposure Data by County

County	Housing Units/sq. mi.	Total Building Exposure ($)	Crop Exposure (2007 Census of Agriculture)*	Social Vulnerability Index (1-5)
Adair	19.9	$2,464,315,000	$18,041,000	1
Andrew	16.9	$1,599,380,000	$40,516,000	2
Atchison	5.5	$650,419,000	$100,418,000	5
Audrain	15.7	$2,442,664,000	$89,405,000	5
Barry	22.5	$3,161,148,000	$6,255,000	1
Barton	9.5	$1,301,748,000	$48,483,000	3
Bates	9.4	$1,598,983,000	$49,679,000	4
Benton	20.1	$2,240,532,000	$10,475,000	4
Bollinger	9.5	$952,545,000	$11,142,000	2
Boone	101.5	$17,363,239,000	$29,169,000	1
Buchanan	94.2	$9,701,152,000	$43,096,000	4
Butler	28.4	$3,682,173,000	$86,624,000	4
Caldwell	10.8	$942,135,000	$19,267,000	2
Callaway	22.2	$4,134,300,000	$29,405,000	1
Camden	62.8	$7,136,339,000	$1,125,000	2

County	Housing Units/sq. mi.	Total Building Exposure ($)	Crop Exposure (2007 Census of Agriculture)*	Social Vulnerability Index (1-5)
Cape Girardeau	56.4	$7,957,433,000	$45,460,000	1
Carroll	6.7	$1,066,261,000	$70,245,000	5
Carter	6.4	$530,088,000	$347,000	4
Cass	57.4	$10,245,424,000	$58,280,000	2
Cedar	15.2	$1,377,577,000	$3,899,000	4
Chariton	5.5	$821,795,000	$67,810,000	5
Christian	56.1	$6,354,341,000	$3,458,000	1
Clark	6.9	$614,995,000	$42,459,000	4
Clay	236.4	$25,240,363,000	$14,232,000	2
Clinton	21.2	$2,143,758,000	$32,487,000	4
Cole	82.1	$9,105,948,000	$8,405,000	1
Cooper	13.2	$1,698,351,000	$42,447,000	1
Crawford	16.1	$2,166,540,000	$1,777,000	1
Dade	8.1	$712,879,000	$19,641,000	5
Dallas	14.2	$1,297,333,000	$3,048,000	4
Daviess	7.5	$865,596,000	$37,669,000	3
DeKalb	10.3	$891,756,000	$26,390,000	1
Dent	9.7	$1,382,572,000	$1,270,000	4
Douglas	8	$1,029,008,000	$1,892,000	2
Dunklin	26.6	$2,492,777,000	$122,818,000	5
Franklin	47.1	$10,276,147,000	$24,032,000	2
Gasconade	15.8	$1,699,937,000	$8,075,000	3
Gentry	6.5	$646,605,000	$26,198,000	1
Greene	185.7	$27,949,700,000	$5,451,000	2
Grundy	11.5	$1,023,068,000	$31,071,000	4
Harrison	6.1	$975,597,000	$41,103,000	3
Henry	15.6	$2,383,450,000	$26,019,000	3
Hickory	17.1	$898,778,000	$1,948,000	5
Holt	6.1	$591,854,000	$74,872,000	4
Howard	9.9	$1,010,144,000	$34,407,000	1
Howell	19.4	$3,408,131,000	$1,779,000	3
Iron	9.7	$960,981,000	$409,000	5
Jackson	516.3	$83,385,516,000	$27,724,000	5
Jasper	79.4	$10,870,600,000	$37,695,000	3
Jefferson	133.4	$20,529,358,000	$5,554,000	2
Johnson	26	$5,052,926,000	$38,226,000	1
Knox	4.5	$398,969,000	$39,560,000	5

County	Housing Units/sq. mi.	Total Building Exposure ($)	Crop Exposure (2007 Census of Agriculture)*	Social Vulnerability Index (1-5)
Laclede	20.6	$2,898,589,000	$3,754,000	2
Lafayette	23.4	$3,519,546,000	$85,068,000	3
Lawrence	27.2	$3,324,370,000	$17,378,000	2
Lewis	9	$899,056,000	$44,189,000	3
Lincoln	33.5	$4,340,031,000	$39,235,000	1
Linn	10.4	$1,313,208,000	$30,588,000	5
Livingston	12.6	$1,385,494,000	$47,535,000	5
Macon	9.6	$1,498,071,000	$31,574,000	4
Madison	12.1	$1,460,266,000	$708,000	5
Maries	8.7	$1,091,078,000	$2,394,000	2
Marion	29.4	$851,638,000	$49,252,000	4
McDonald	18.4	$2,789,835,000	$2,490,000	1
Mercer	4.7	$367,552,000	$14,186,000	4
Miller	21.5	$2,194,585,000	$3,820,000	4
Mississippi	13.9	$1,066,614,000	$104,434,000	5
Moniteau	39.5	$1,315,933,000	$17,069,000	1
Monroe	14.9	$900,582,000	$41,900,000	3
Montgomery	7.4	$1,254,588,000	$39,049,000	3
Morgan	11.4	$2,518,783,000	$11,237,000	2
New Madrid	26	$1,569,929,000	$141,223,000	5
Newton	12.6	$5,027,857,000	$10,906,000	1
Nodaway	38.9	$2,097,395,000	$88,341,000	1
Oregon	10.9	$842,686,000	$1,116,000	3
Osage	6.9	$1,427,835,000	$7,816,000	2
Ozark	10.8	$784,866,000	$817,000	4
Pemiscot	7.6	$1,433,654,000	$100,096,000	5
Perry	16.6	$2,124,249,000	$25,608,000	3
Pettis	18.1	$4,311,203,000	$52,648,000	2
Phelps	26.7	$4,283,040,000	$1,510,000	1
Pike	29.1	$1,732,955,000	$49,657,000	1
Platte	11.7	$10,180,565,000	$43,973,000	4
Polk	93.3	$2,506,838,000	$6,054,000	1
Pulaski	20.9	$3,755,326,000	$948,000	2
Putnam	32.7	$493,213,000	$13,921,000	5
Ralls	5.8	$1,036,049,000	$42,557,000	1
Randolph	11	$2,337,954,000	$18,602,000	4
Ray	22.2	$2,357,316,000	$35,783,000	2

County	Housing Units/sq. mi.	Total Building Exposure ($)	Crop Exposure (2007 Census of Agriculture)*	Social Vulnerability Index (1-5)
Reynolds	17.6	$717,542,000	$325,000	3
Ripley	5	$1,050,116,000	$6,640,000	3
Saline	10.5	$2,326,438,000	$116,807,000	2
Schuyler	13.4	$369,094,000	$6,584,000	5
Scotland	6.8	$475,226,000	$31,106,000	4
Scott	5.4	$3,636,518,000	$83,342,000	4
Shannon	40.4	$725,557,000	$636,000	5
Shelby	4.1	$677,622,000	$52,083,000	3
St. Charles	6.4	$39,157,150,000	$40,965,000	3
St. Clair	251.6	$949,294,000	$15,474,000	5
St. Francois	8.4	$6,073,289,000	$2,673,000	3
St. Louis	63	$41,414,257,000	$23,414,000	5
St. Louis City*	2842.9	$127,497,738,000	$0	4
Ste. Genevieve	862.6	$1,967,405,000	$12,265,000	3
Stoddard	17.3	$2,589,294,000	$166,828,000	3
Stone	16.5	$3,376,042,000	$1,789,000	3
Sullivan	43.9	$566,143,000	$13,041,000	2
Taney	5.2	$4,708,947,000	$790,000	2
Texas	46.3	$2,059,876,000	$3,898,000	5
Vernon	9.9	$2,352,179,000	$39,281,000	3
Warren	11.5	$3,105,665,000	$18,134,000	1
Washington	34.3	$1,678,841,000	$711,000	2
Wayne	14.5	$1,181,550,000	$1,389,000	4
Webster	10.6	$2,628,891,000	$5,022,000	2
Worth	24.3	$248,027,000	$11,069,000	5
Wright	4.8	$1,489,037,000	$1,977,000	3

*Respondents to the USDA's 2012 Crop Census were required to respond by February 4, 2013. At the time this plan was published, the updated data was not available from the USDA.

Table 3.5.6b provides the additional data obtained to complete the overall vulnerability analysis.

Table 3.5.6b Additional Statistical Data Compiled for Vulnerability Analysis

County	Total Hail Incidents	Total Hail Property Loss ($)	Total Crop Insurance Paid for Hail Damage ($)	Total Wind Incidents ($)	Total Wind Property Loss ($)	Total Crop Insurance Paid for Wind Damage ($)	Total Lightning Incidents	Total Lightning Property Loss ($)
Adair	54	$23,000	$28,841	32	$663,000	$0	1	$200,000

County	Total Hail Incidents	Total Hail Property Loss ($)	Total Crop Insurance Paid for Hail Damage ($)	Total Wind Incidents ($)	Total Wind Property Loss ($)	Total Crop Insurance Paid for Wind Damage ($)	Total Lightning Incidents	Total Lightning Property Loss ($)
Andrew	76	$108,000	$1,238,598	30	$36,000	$107279	0	$0
Atchison	112	$1,050,000	$1,962,349	56	$164,000	$1,468,177	0	$0
Audrain	15	$0	$271,814	0	$0	$172,076	0	$0
Barry	176	$122,000	$0	57	$1,281,000	$901	0	$0
Barton	137	$37,000	$176,376	50	$353,500	$14,928	1	$10,000
Bates	104	$6,897,000	$249,653	22	$12,000	$33,633	1	$2,000
Benton	93	$51,000	$11,696	84	$629,000	$7,260	2	$15,000
Bollinger	78	$1,612,500	$792	51	$8,845,000	$0	1	$10,000
Boone	218	$19,500	$17,771	128	$141,500	$15,790	14	$690,000
Buchanan	97	$20,000	$297,634	61	$1,270,000	$79,418	0	$0
Butler	87	$1,406,000	$4,381	78	$1,838,500	$12,714	1	$10,000
Caldwell	68	$80,000	$85,792	48	$211,000	$112,754	0	$0
Callaway	105	$157,000	$54,729	91	$608,800	$40,761	5	$20,000
Camden	145	$18,000	$0	103	$1,107,000	$0	4	$1,002,000
Cape Girardeau	99	$397,000	$0	102	$5,118,000	$28,220	7	$52,000
Carroll	78	$5,500	$270,961	40	$306,000	$129,486	0	$0
Carter	51	$84,600	$0	36	$369,000	$0	1	$0
Cass	230	$3,544,000	$50,478	103	$525,500	$33,061	1	$25,000
Cedar	87	$5,000	$42,743	72	$7,275,000	$0	1	$55,000
Chariton	61	$1,500,000	$64,443	38	$105,000	$26,831	0	$0
Christian	164	$71,000	$0	141	$10,348,000	$0	4	$330,000
Clark	53	$2,191,500	$19,166	60	$617,400	$6,389	1	$0
Clay	207	$4,520,500	$142,496	137	$2,168,500	$17,192	0	$0
Clinton	104	$5,000	$192,526	51	$639,750	$10,010	0	$0
Cole	82	$0	$5,167	52	$1,156,600		8	$35,000
Cooper	91	$20,000	$63,122	37	$208,000	$439,398	1	$5,000
Crawford	88	$5,000	$0	66	$194,300	$0	1	$0
Dade	92	$56,000	$91,861	70	$1,819,000	$0	1	$55,000

County	Total Hail Incidents	Total Hail Property Loss ($)	Total Crop Insurance Paid for Hail Damage ($)	Total Wind Incidents ($)	Total Wind Property Loss ($)	Total Crop Insurance Paid for Wind Damage ($)	Total Lightning Incidents	Total Lightning Property Loss ($)
Dallas	92	$116,500	$0	72	$3,453,000	$0	1	$0
Daviess	106	$565,000	$257,293	72	$617,250	$18,521	1	$5,000
DeKalb	94	$260,000	$462,458	48	$754,300	$324,382	0	$0
Dent	75	$19,000	$0	68	$1,279,800	$0	0	$0
Douglas	115	$387,500	$0	94	$5,172,000	$0	3	$60,000
Dunklin	86	$114,000	$106,935	92	$802,510	$376,903	1	$1,000
Franklin	175	$550,000	$1,131	157	$834,500	$8,098	2	$0
Gasconade	92	$1,000,000	$0	67	$1,191,600	$0	2	$125,800
Gentry	68	$5,650,000	$1,271,530	39	$146,450	$114,497	0	$0
Greene	333	$784,700	$0	303	$16,527,600	$0	5	$65,000
Grundy	103	$300,000	$237,442	50	$100,600	$186,144	0	$0
Harrison	81	$105,000	$487,833	41	$123,000	$26,379	0	$0
Henry	78	$1,000	$27,024	57	$1,187,100	$40,546	1	$0
Hickory	68	$12,000	$38,634	54	$145,000	$7,846	0	$0
Holt	76	$157,000	$407,318	25	$674,000	$204,784	0	$0
Howard	69	$110,000	$29,664	27	$324,000	$21,363	0	$0
Howell	158	$307,000	$0	120	$4,260,000	$0	4	$64,000
Iron	53	$10,100	$0	45	$1,000	$0	1	$0
Jackson	351	$15,333,000	$202,070	192	$13,029,500	$347,302	11	$538,000
Jasper	149	$136,000	$72,918	172	$5,674,000	$12,141	7	$580,000
Jefferson	175	$569,000	$0	101	$181,700	$0	7	$52,000
Johnson	150	$66,000	$23,245	108	$304,750	$193,998	2	$25,000
Knox	35	$5,000	$98,532	32	$10,500	$11,254	0	$0
Laclede	134	$35,500	$0	119	$1,640,000	$0	5	$544,500
Lafayette	80	$325,000	$2,192,123	75	$232,000	$513,698	0	$0
Lawrence	143	$6,115,000	$175,625	89	$5,198,000	$6,149	3	$0
Lewis	67	$35,000	$49,381	60	$0	$26,545	3	$0
Lincoln	66	$5,500	$31,046	84	$25,400	$167,508	1	$0

County	Total Hail Incidents	Total Hail Property Loss ($)	Total Crop Insurance Paid for Hail Damage ($)	Total Wind Incidents ($)	Total Wind Property Loss ($)	Total Crop Insurance Paid for Wind Damage ($)	Total Lightning Incidents	Total Lightning Property Loss ($)
Linn	69	$1,500,000	$47,402	39	$182,000	$136,340	0	$0
Livingston	68	$300,000	$30,222	45	$658,700	$2,361	0	$0
Macon	82	$1,000	$308,997	52	$320,300	$2,481	0	$0
Madison	38	$500	$0	33	$250,500	$0	0	$0
Maries	65	$5,000	$0	47	$688,500	$2,019	0	$0
Marion	62	$1,000,000	$84,903	48	$111,500	$72,098	4	$25,200
McDonald	105	$563,800	$0	83	$719,000	$0	1	$10,000
Mercer	62	$30,000	$124,662	22	$66,000	$40,532	0	$0
Miller	120	$53,000	$0	65	$370,500	$0	0	$0
Mississippi	28	$200,000	$110,948	52	$1,862,000	$110,755	2	$30,000
Moniteau	63	$10,000	$0	52	$66,300	$1,158	1	$200,000
Monroe	36	$10,000	$21,332	51	$56,100	$9,035	0	$0
Montgomery	65	$5,500	$363,767	60	$51,200	$45,370	0	$0
Morgan	122	$110,000	$55,685	70	$1,450,000	$0	2	$65,000
New Madrid	38	$2,000	$342,188	49	$1,128,000	$532,855	1	$0
Newton	176	$146,100	$95,841	92	$3,672,500	$0	4	$63,000
Nodaway	144	$10,000	$9,503,250	82	$1,935,700	$659,011	0	$0
Oregon	74	$7,000	$0	58	$1,160,000	$0	0	$0
Osage	66	$0	$0	30	$43,000	$14,080	0	$0
Ozark	128	$101,000	$0	95	$3,829,000	$0	1	$70,000
Pemiscot	54	$83,500	$1,127,636	66	$1,228,000	$220,202	0	$0
Perry	35	$6,010,500	$0	50	$51,393,500	$0	2	$1,000
Pettis	93	$2,100,000	$120,733	71	$411,300	$99,690	3	$40,000
Phelps	133	$12,400	$0	77	$1,116,100	$0	3	$205,000
Pike	63	$0	$24,702	68	$28,000	$76,618	1	$10,000
Platte	161	$1,385,000	$1,254,056	93	$542,000	$232,020	1	$100,000
Polk	158	$75,800	$0	119	$7,741,500	$0	0	$0
Pulaski	143	$94,000	$10,432	83	$290,500	$0	1	$0

County	Total Hail Incidents	Total Hail Property Loss ($)	Total Crop Insurance Paid for Hail Damage ($)	Total Wind Incidents ($)	Total Wind Property Loss ($)	Total Crop Insurance Paid for Wind Damage ($)	Total Lightning Incidents	Total Lightning Property Loss ($)
Putnam	41	$0	$4,167	23	$282,000	$27,045	0	$0
Ralls	44	$0	$74,000	62	$39,400	$32,760	4	$0
Randolph	46	$4,000	$918	46	$344,300	$0	0	$0
Ray	72	$5,000	$178,709	50	$992,000	$21,654	2	$10,000
Reynolds	35	$50,000	$0	40	$111,300	$0	2	$55,000
Ripley	60	$15,500	$16,278	45	$1,464,000	$11,359	0	$0
Saline	59	$205,500	$623,738	39	$1,078,000	$346,509	0	$0
Schuyler	23	$0	$9,160	17	$217,000	$2,877	0	$0
Scotland	49	$3,611,500	$85,531	51	$352,600	$20,751	3	$265,000
Scott	71	$715,000	$100,548	73	$2,109,000	$124,400	3	$90,000
Shannon	83	$500	$0	75	$3,186,000	$0	0	$0
Shelby	30	$0	$126,916	36	$39,500	$42,074	5	$157,000
St. Charles	180	$200,055,000	$118,703	187	$2,644,300	$2,882	5	$15,000
St. Clair	100	$10,500	$29,174	64	$389,000	$0	2	$18,000
St. Francois	70	$18,000	$0	69	$446,400	$0	5	$100,000
St. Louis	350	$857,310,600	$0	296	$563,000	$463	12	$270,000
St. Louis City*	38	$750,000	$0	45	$619,000	$0	3	$5,000
Ste. Genevieve	47	$3,500	$189	66	$78,500	$5,824	5	$7,000
Stoddard	81	$116,000	$982,585	72	$2,196,500	$304,522	3	$20,000
Stone	176	$221,400	$0	78	$3,408,000	$0	2	$500,000
Sullivan	48	$3,000	$8,851	34	$107,500	$30,886	0	$0
Taney	118	$555,100	$0	82	$1,691,000	$0	2	$30,000
Texas	147	$239,600	$0	75	$1,193,000	$0	1	$0
Vernon	139	$2,200	$38,892	101	$651,000	$0	1	$18,000
Warren	54	$0	$1,412	63	$14,800	$45,106	3	$0
Washington	116	$1,200	$0	63	$504,000	$0	0	$0
Wayne	73	$170,000	$0	45	$1,026,000	$0	2	$0
Webster	137	$44,100	$0	102	$7,023,100	$0	0	$0

County	Total Hail Incidents	Total Hail Property Loss ($)	Total Crop Insurance Paid for Hail Damage ($)	Total Wind Incidents ($)	Total Wind Property Loss ($)	Total Crop Insurance Paid for Wind Damage ($)	Total Lightning Incidents	Total Lightning Property Loss ($)
Worth	54	$0	$82,159	12	$10,000	$4,125	0	$0
Wright	128	$802,500	$0	101	$3,977,000	$0	1	$60,000

From this statistical data collected, five factors were considered in determining overall vulnerability to lightning as follows: housing density, likelihood of occurrence, building exposure, average annual property loss ratio, and social vulnerability. For hail and wind, the two additional factors of crop exposure and average annual crop insurance claims as a result of these hazards were considered.

To complete the vulnerability analysis utilizing the factors described above, a rating value of 1-5 was assigned to the data obtained for each factor. These rating values correspond to the following descriptive terms:

1) Low
2) Medium-low
3) Medium
4) Medium-high
5) High

The rating values of all factors were then combined to determine the overall vulnerability rating. Table 3.5.6c below provides the factors considered and the ranges for the rating values assigned.

Table 3.5.6c Ranges for Severe Thunderstorm Vulnerability Factor Ratings

Factors Considered	Low (1)	Medium-low (2)	Medium (3)	Medium-high-4	High (5)
Common Factors					
Housing Density (# per sq. mile)	<50	50 to 99	100 to 299	300 to 499	>500
Crop Exposure ($ in millions) (hail and wind only)	<$10,000	$10,000 to $24,999	$25,000 to $49,999	$50,000 to $99,999	>$100,000
Social Vulnerability	1	2	3	4	5
Wind					
Likelihood of Occurrence (# of events/ yrs. of data)	0 to 2.15	2.16 to 3.73	3.74 to 5.68	5.60 to 10.10	10.11 to 15.95
Average Annual Property Loss Ratio (annual property loss/ exposure)	0.00 – 0.000027	0.000028 – 0.000092	0.000093 – 0.000231	0.000232 – 0.000489	0.000490 – 0.001273
Wind Crop Loss Ratio (annual crop claims/ exposure)	0 – 0.000084	0.000085 – 0.000250	0.000251 – 0.000714	0.000715 – 0.001398	0.001399 – 0.003574
Hail					
Likelihood of Occurrence (# of events/ yrs. of data)	0.78 to 3.10	3.11 to 5.26	5.27 to 7.89	7.90 to 12.10	12.11 to 18.48

Factors Considered	Low (1)	Medium-low (2)	Medium (3)	Medium-high-4	High (5)
Average Annual Property Loss Ratio (annual property loss/ exposure)	0 – 0.000034	0.000035 – 0.000149	0.000150 – 0.000269	0.000280 – 0.000460	0.000461 – 0.001090
Hail Crop Loss Ratio (annual crop claims/ exposure)	0 – 0.000270	0.000271 – 0.000974	0.000975 – 0.002304	0.002305 – 0.003698	0.003699 – 0.007516
Lightning					
Likelihood of Occurrence (# of events/ yrs. of data)	0 to 0.05	0.06 to 0.15	0.16 to 0.26	0.27 to 0.42	0.43 to 0.74
Average Annual Property Loss Ratio (annual property loss/ exposure)	0 – 0.000001	0.000002 – 0.000003	0.000004 – 0.000006	0.000007 – 0.000015	0.000016 – 0.000037

Figure 3.5.6.1, Figure 3.5.6.2, and Figure 3.5.6.3 provide the likelihood of occurrence for wind, hail, and lightning events in Missouri counties based on the historical events reported in the NCDC database for the period from 1993 to December 2012.

Figure 3.5.6.1 - Likelihood of Occurrence of High Wind Events (67 MPH and higher)

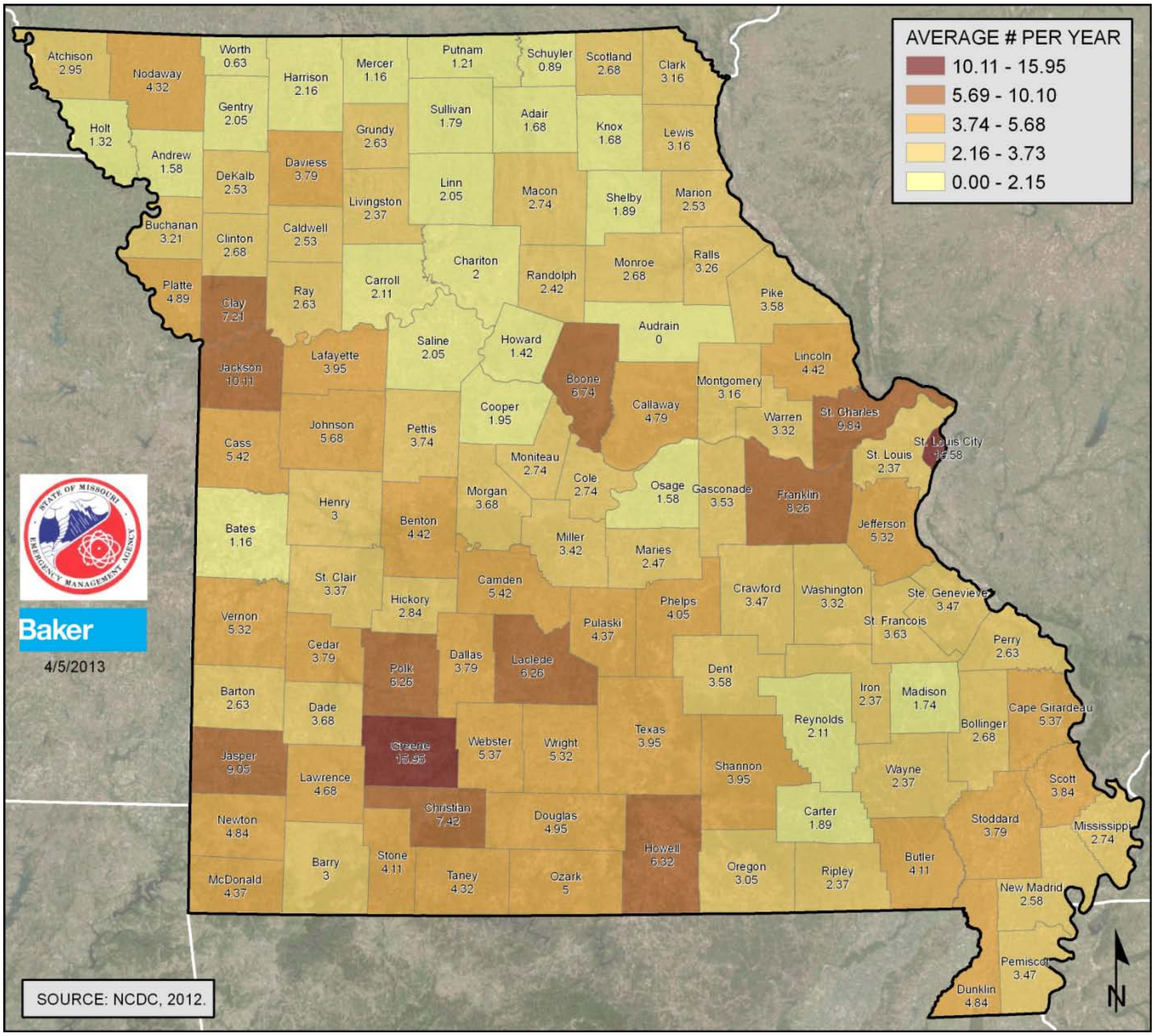


Figure 3.5.6.2 - Likelihood of Occurrence of Damaging Hail Events (.75 inches and larger)

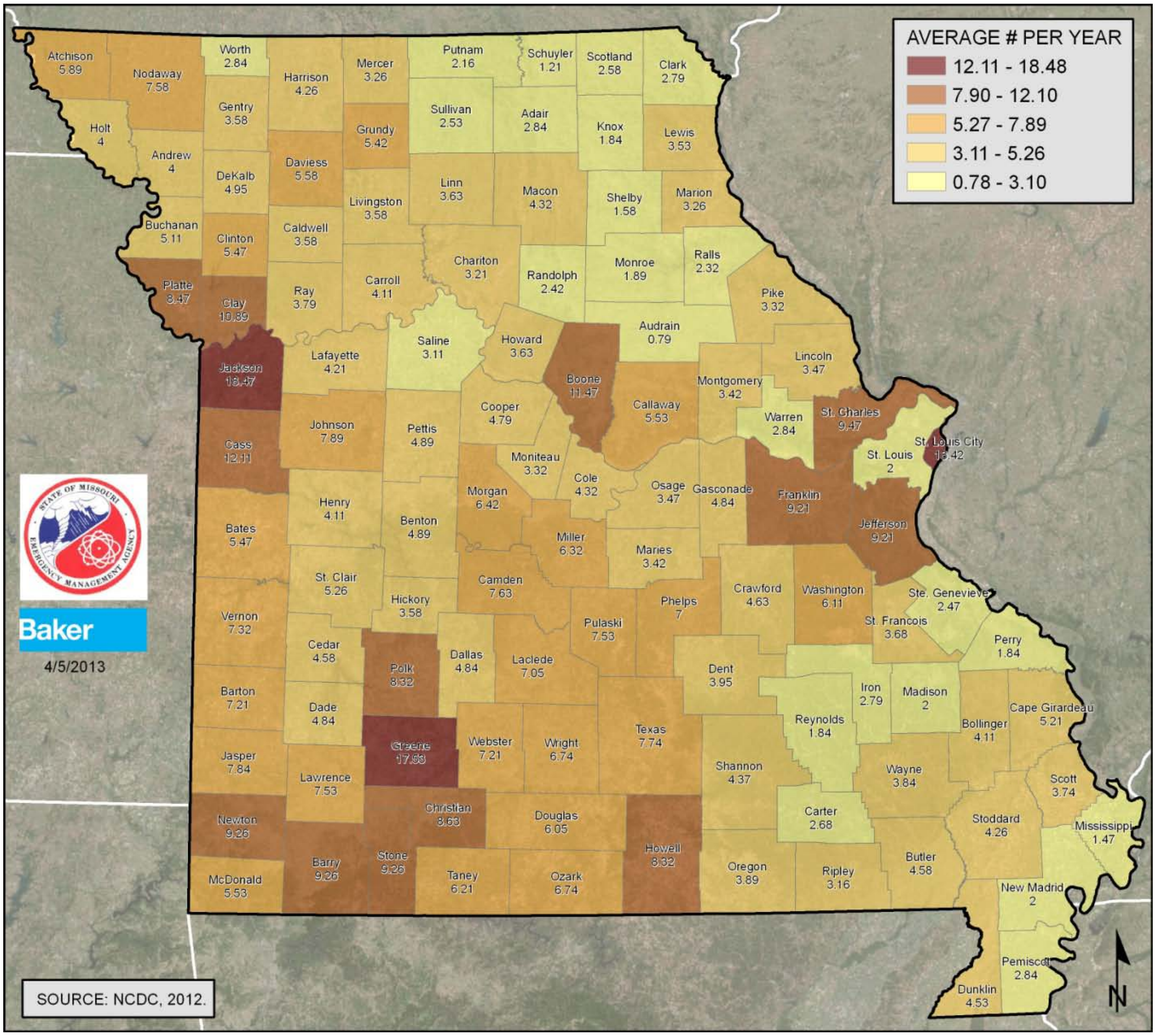
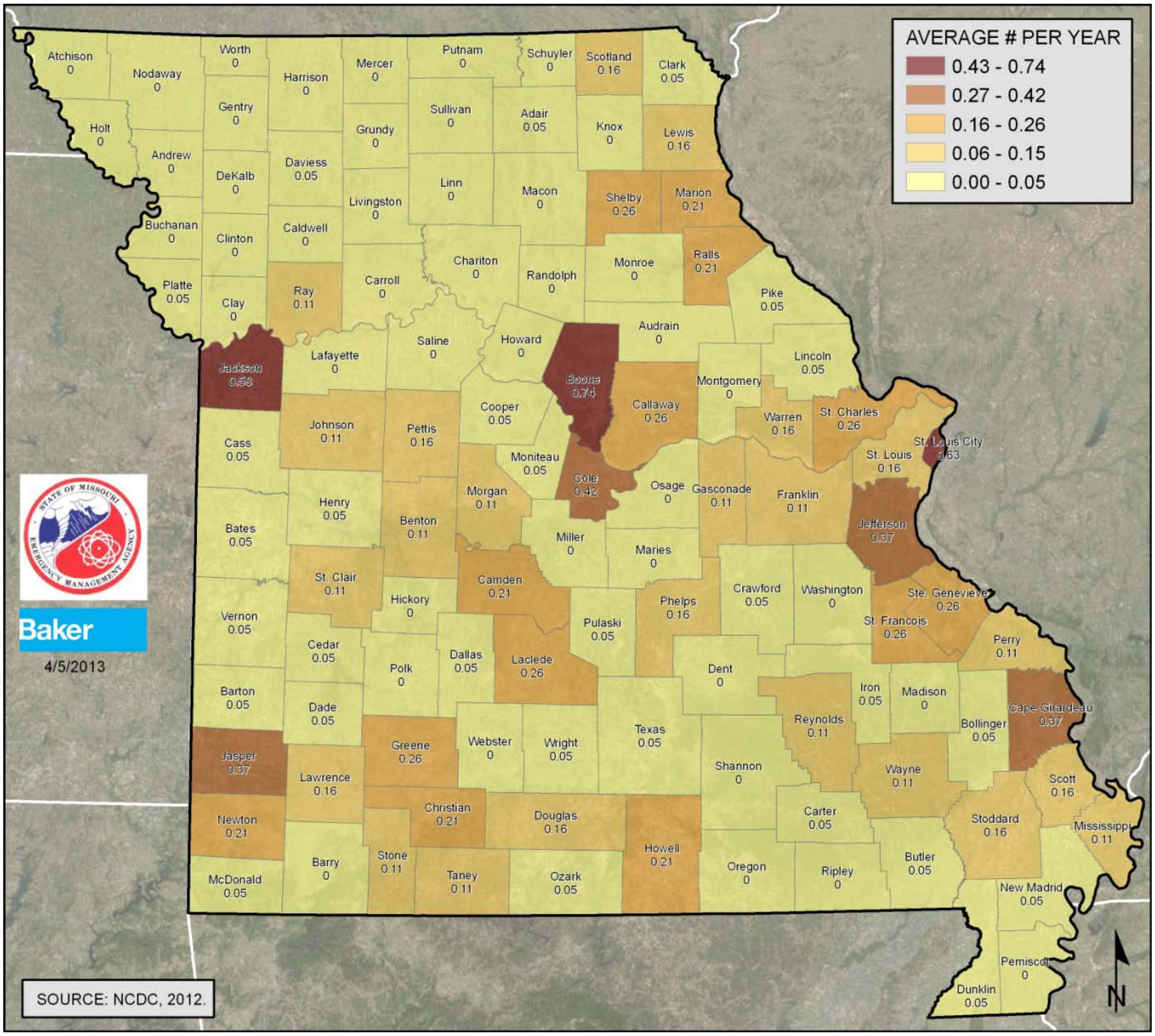


Figure 3.5.6.3 - Likelihood of Occurrence of Damaging Lightning Events



Once the ranges were determined and applied to all factors considered in the analysis for wind, hail, and lightning, they were weighted equally and factored together to determine an overall vulnerability rating. Once the overall vulnerability rating was determined for the three event types, a combined vulnerability rating was computed. In calculating the combined vulnerability rating, the hail and wind events were factored in with a multiplier of 2 since these events generally cause more damages. Table 3.5.6d provides the calculated ranges applied to determine overall vulnerability of Missouri counties to severe thunderstorms and Table 3.5.6e provides the calculated vulnerability ratings for wind, hail, and lightning as well as the calculated combined vulnerability rating for the severe thunderstorm hazard. Figure 3.5.6.4 that follows provides the mapped results of this analysis by county.

Table 3.5.6d Ranges for Severe Thunderstorm Combined Vulnerability Rating

	Low (1)	Medium-low (2)	Medium (3)	Medium-high (4)	High (5)
Severe Thunderstorm Combined Vulnerability	9 to 11	12 to 14	15 to 17	18 to 20	21 to 26

Table 3.5.6e Severe Thunderstorm Combined Vulnerability Rating

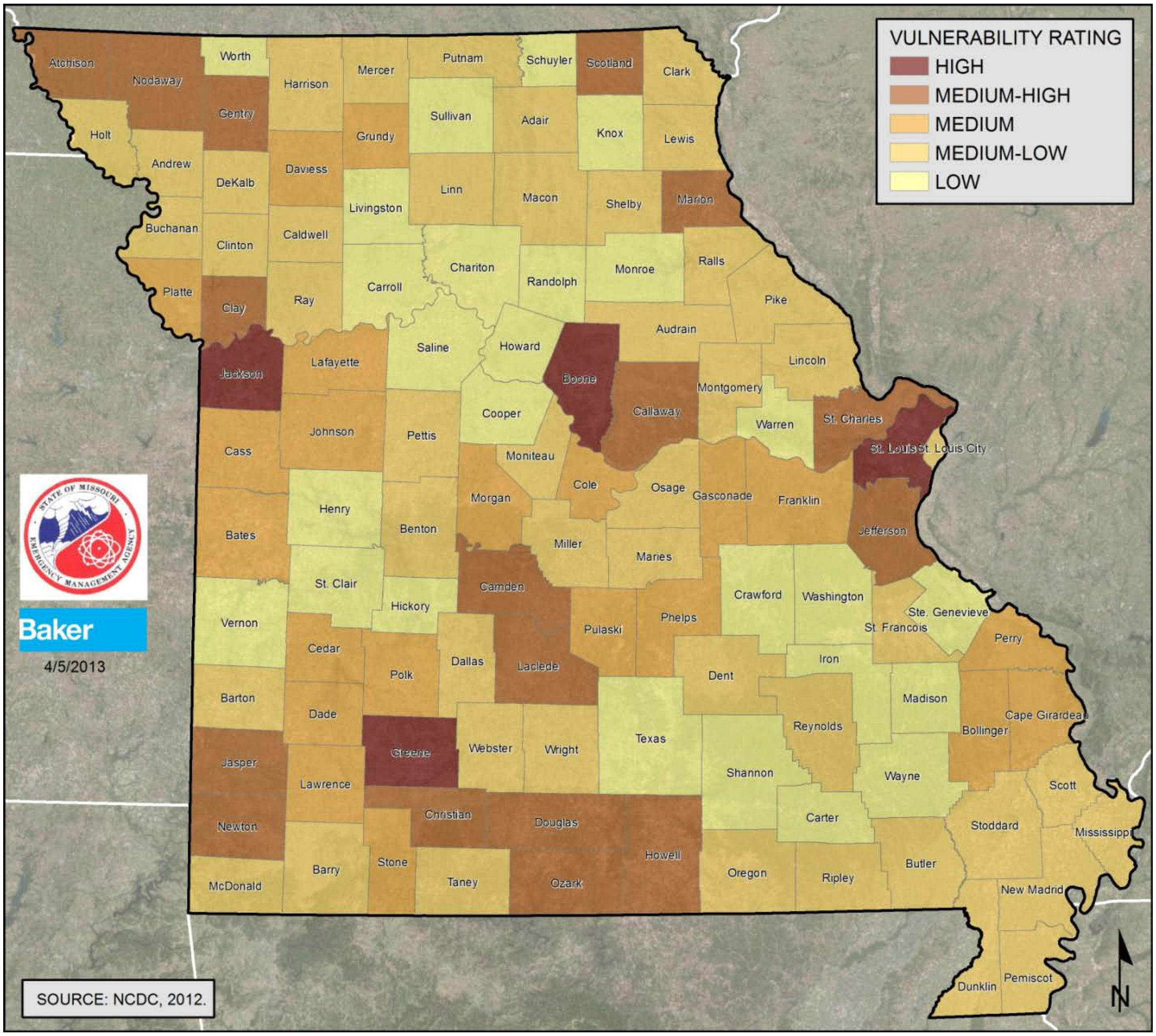
County	Housing Density Rating	Wind Likelihood Rating	Annualized Wind Property Loss	Annualized Wind Crop Loss	Hail Likelihood Rating	Annualized Hail Property Loss	Annualized Hail Crop Loss	Lightning Likelihood Rating	Annualized Lightning Property Loss	Total Thunderstorm Vulnerability	Combined Vulnerability
Adair	1	1	1	1	1	1	2	1	3	12	Medium-Low
Andrew	1	1	1	2	2	1	2	1	1	12	Medium-Low
Atchison	1	2	1	5	3	2	4	1	1	20	Medium-High
Audrain	1	1	1	3	1	1	2	1	1	12	Medium-Low
Barry	1	2	1	1	4	1	1	1	1	13	Medium-Low
Barton	1	2	1	1	3	1	2	1	1	13	Medium-Low
Bates	1	1	1	2	3	3	3	1	1	16	Medium
Benton	1	3	1	1	2	1	2	2	1	14	Medium-Low
Bollinger	1	2	4	1	2	2	1	1	1	15	Medium
Boone	2	4	1	2	4	1	1	5	2	22	High
Buchanan	2	2	1	2	2	1	2	1	1	14	Medium-Low
Butler	1	3	1	1	2	1	1	1	1	12	Medium-Low
Caldwell	1	2	1	2	2	1	2	1	1	13	Medium-Low
Callaway	1	3	1	3	3	1	2	3	1	18	Medium-High
Camden	2	3	1	1	3	1	1	3	4	19	Medium-High
Cape Girardeau	2	3	2	1	2	1	1	4	1	17	Medium
Carroll	1	1	1	1	2	1	2	1	1	11	Low
Carter	1	1	2	1	1	1	1	1	1	10	Low
Cass	2	3	1	1	4	1	1	1	1	15	Medium
Cedar	1	3	4	1	2	1	2	1	2	17	Medium
Chariton	1	1	1	1	2	2	1	1	1	11	Low
Christian	2	4	2	1	4	1	1	3	2	20	Medium-High

County	Housing Density Rating	Wind Likelihood Rating	Annualized Wind Property Loss	Annualized Wind Crop Loss	Hail Likelihood Rating	Annualized Hail Property Loss	Annualized Hail Crop Loss	Lightning Likelihood Rating	Annualized Lightning Property Loss	Total Thunderstorm Vulnerability	Combined Vulnerability
Clark	1	2	2	1	1	3	1	1	1	13	Medium-Low
Clay	3	4	1	1	4	1	3	1	1	19	Medium-High
Clinton	1	2	1	1	3	1	2	1	1	13	Medium-Low
Cole	2	2	1	1	2	1	1	4	1	15	Medium
Cooper	1	1	1	1	2	1	1	1	1	10	Low
Crawford	1	2	1	1	2	1	1	1	1	11	Low
Dade	1	2	3	1	2	1	2	1	3	16	Medium
Dallas	1	3	3	1	2	1	1	1	1	14	Medium-Low
Daviess	1	3	2	1	3	1	2	1	1	15	Medium
DeKalb	1	2	2	1	2	1	3	1	1	14	Medium-Low
Dent	1	2	2	1	2	1	1	1	1	12	Medium-Low
Douglas	1	3	4	1	3	1	1	2	3	19	Medium-High
Dunklin	1	3	1	3	2	1	1	1	1	14	Medium-Low
Franklin	2	4	1	1	4	1	1	2	1	17	Medium
Gasconade	1	2	2	1	2	1	1	2	3	15	Medium
Gentry	1	1	1	2	2	4	5	1	1	18	Medium-High
Greene	3	5	2	1	5	1	1	3	1	22	High
Grundy	1	2	1	4	3	1	3	1	1	17	Medium
Harrison	1	1	1	1	2	1	3	1	1	12	Medium-Low
Henry	1	2	1	1	2	1	1	1	1	11	Low
Hickory	1	2	1	1	2	1	1	1	1	11	Low
Holt	1	1	2	3	2	1	1	1	1	13	Medium-Low
Howard	1	1	1	1	2	1	1	1	1	10	Low
Howell	1	4	2	1	4	1	1	3	1	18	Medium-High
Iron	1	2	1	1	1	1	1	1	1	10	Low
Jackson	4	4	1	2	5	1	3	5	1	26	High
Jasper	2	4	1	1	3	1	1	4	3	20	Medium-High
Jefferson	2	3	1	1	4	1	1	4	1	18	Medium-High
Johnson	1	3	1	2	3	1	1	2	1	15	Medium
Knox	1	1	1	1	1	1	1	1	1	9	Low
Laclede	1	4	2	1	3	1	1	3	4	20	Medium-High
Lafayette	1	3	1	2	2	1	4	1	1	16	Medium
Lawrence	1	3	2	1	3	2	1	2	1	16	Medium

County	Housing Density Rating	Wind Likelihood Rating	Annualized Wind Property Loss	Annualized Wind Crop Loss	Hail Likelihood Rating	Annualized Hail Property Loss	Annualized Hail Crop Loss	Lightning Likelihood Rating	Annualized Lightning Property Loss	Total Thunderstorm Vulnerability	Combined Vulnerability
Lewis	1	2	1	2	2	1	1	2	1	13	Medium-Low
Lincoln	1	3	1	1	2	1	1	1	1	12	Medium-Low
Linn	1	1	1	2	2	2	2	1	1	13	Medium-Low
Livingston	1	2	1	1	2	1	1	1	1	11	Low
Macon	1	2	1	1	2	1	3	1	1	13	Medium-Low
Madison	1	1	1	1	1	1	1	1	1	9	Low
Maries	1	2	2	2	2	1	1	1	1	13	Medium-Low
Marion	1	2	1	3	2	2	2	3	2	18	Medium-High
McDonald	1	3	1	1	3	1	1	1	1	13	Medium-Low
Mercer	1	1	1	3	2	1	3	1	1	14	Medium-Low
Miller	1	2	1	1	3	1	1	1	1	12	Medium-Low
Mississippi	1	2	2	2	1	1	1	2	2	14	Medium-Low
Moniteau	1	2	1	1	2	1	1	1	4	14	Medium-Low
Monroe	1	2	1	1	1	1	1	1	1	10	Low
Montgomery	1	2	1	2	2	1	3	1	1	14	Medium-Low
Morgan	1	2	2	1	3	1	3	2	2	17	Medium
New Madrid	1	2	2	2	1	1	1	1	1	12	Medium-Low
Newton	1	3	2	1	4	1	3	3	1	19	Medium-High
Nodaway	1	3	2	3	3	1	3	1	1	18	Medium-High
Oregon	1	2	2	1	2	1	1	1	1	12	Medium-Low
Osage	1	1	1	3	2	1	1	1	1	12	Medium-Low
Ozark	1	3	4	1	3	1	1	1	3	18	Medium-High
Pemiscot	1	2	2	2	1	1	3	1	1	14	Medium-Low
Perry	1	2	5	1	1	2	1	2	1	16	Medium
Pettis	1	2	1	1	2	1	1	2	1	12	Medium-Low
Phelps	1	3	1	1	3	1	1	2	2	15	Medium
Pike	1	2	1	3	2	1	1	1	1	13	Medium-Low
Platte	1	3	1	2	4	1	2	1	1	16	Medium
Polk	1	4	3	1	4	1	1	1	1	17	Medium
Pulaski	1	3	1	1	3	1	4	1	1	16	Medium
Putnam	1	1	2	3	1	1	1	1	1	12	Medium-Low
Ralls	1	2	1	2	1	1	1	3	1	13	Medium-Low
Randolph	1	2	1	1	1	1	1	1	1	10	Low

County	Housing Density Rating	Wind Likelihood Rating	Annualized Wind Property Loss	Annualized Wind Crop Loss	Hail Likelihood Rating	Annualized Hail Property Loss	Annualized Hail Crop Loss	Lightning Likelihood Rating	Annualized Lightning Property Loss	Total Thunderstorm Vulnerability	Combined Vulnerability
Ray	1	2	1	1	2	1	2	2	1	13	Medium-Low
Reynolds	1	1	1	1	1	1	1	2	3	12	Medium-Low
Ripley	1		2	3	2	1	1	1	1	12	Medium-Low
Saline	1		1	1	1	1	2	1	1	9	Low
Schuyler	1		2	2	1	1	1	1	1	10	Low
Scotland	1		2	2	1	4	2	2	5	19	Medium-High
Scott	1		2	3	2	1	1	2	2	14	Medium-Low
Shannon	1		3	1	2	1	1	1	1	11	Low
Shelby	1		1	1	1	1	1	3	4	13	Medium-Low
St. Charles	3		1	1	4	3	2	3	1	18	Medium-High
St. Clair	1		1	1	2	1	2	2	1	11	Low
St. Francois	2		1	1	2	1	1	3	1	12	Medium-Low
St. Louis	4		1	1	5	5	1	5	1	23	High
St. Louis City*	5		1	1	1	1	1	2	1	13	Medium-Low
Ste. Genevieve	1		1	2	1	1	1	3	1	11	Low
Stoddard	1		2	3	2	1	2	2	1	14	Medium-Low
Stone	2		2	1	4	1	1	2	4	17	Medium
Sullivan	1		1	2	1	1	1	1	1	9	Low
Taney	2		1	1	3	1	1	2	1	12	Medium-Low
Texas	1		2	1	3	1	1	1	1	11	Low
Vernon	1		1	1	3	1	1	1	1	10	Low
Warren	1		1	1	1	1	1	2	1	9	Low
Washington	1		1	1	3	1	1	1	1	10	Low
Wayne	1		2	1	2	1	1	2	1	11	Low
Webster	1		3	1	3	1	1	1	1	12	Medium-Low
Worth	1		1	1	1	1	3	1	1	10	Low
Wright	1		3	1	3	1	1	1	2	13	Medium-Low

Figure 3.5.6.4 - Vulnerability Summary for Severe Thunderstorm



Overview and Analysis of Potential Loss Estimates to Severe Thunderstorms

Severe thunderstorms and the associated wind, hail and lightning cause deaths and injuries annually in the United States. During the 20.5 year period from 1993 to May 2013, there were a combined 36 deaths and 452 injuries reported to NCDC resulting from high winds, hail, and lightning in Missouri. This translates to an annualized occurrence of 1.75 deaths and 22.05 injuries. With so many variables involved in death and injury occurrences, it is difficult to estimate future occurrences. However, it is noted that death and injury do occur annually in Missouri as a result of the severe thunderstorm hazard.

To determine potential financial loss estimates to severe thunderstorms in Missouri, the available historical loss data was annualized. In the case of frequently occurring weather-related hazards such as severe thunderstorms, annualized historical loss data is considered to be the best resource for determining future potential losses. As discussed above in the vulnerability overview for this hazard, the planning team obtained historical loss data from the National Climatic Database for wind, hail, and

lightning for the period from 1993 to July 2013. In addition, since agriculture plays such an important role in the Missouri economy, it is important to note that crop damage was roughly $63,232,281 and property damage was $270,339,732 as a result of wind and hail for the period from 1993 to 2013. According to this data, the combined annualized property loss to the State of Missouri as a result of severe thunderstorms (wind, hail, and lightning) is $1,576,189,363 . Figure 3.5.6.x highlights that wind has an annualized property loss of $13,187,304 hail losses of $63,232,281, and lightning losses of $467,700 for a total of $76,887,286 annualized losses.

Table 3.5.6f provides the annualized total loss estimates (property and crop) for all counties in Missouri and the independent City of St. Louis.

Table 3.5.6f Annualized Severe Thunderstorm Damages in Missouri

County	Annualized Property Loss and Crop Claims-Wind ($)	Annualized Property Loss and Crop Claims-Hail ($)	Annualized Property Loss-Lightning ($)	Combined Annualized Losses (wind, hail, lightning) ($)
Adair	$34,894.74	$4,815.65	$13,333.33	$53,044
Andrew	$15,304.61	$160,508.96	$0.00	$175,814
Atchison	$192,153.70	$300,556.78	$0.00	$492,710
Audrain	$21,509.50	$33,976.75	$0.00	$55,486
Barry	$67,533.68	$6,421.05	$0.00	$73,955
Barton	$20,471.26	$23,994.37	$666.67	$45,132
Bates	$4,835.70	$394,206.63	$133.33	$399,176
Benton	$34,012.76	$4,146.21	$1,000.00	$39,159
Bollinger	$465,526.32	$84,967.42	$666.67	$551,160
Boone	$9,421.12	$3,247.69	$46,000.00	$58,669
Buchanan	$76,769.36	$38,256.88	$0.00	$115,026
Butler	$98,352.41	$74,547.63	$666.67	$173,567
Caldwell	$25,199.51	$14,934.53	$0.00	$40,134
Callaway	$37,137.23	$15,104.28	$1,333.33	$53,575
Camden	$58,263.16	$947.37	$66,800.00	$126,011
Cape Girardeau	$272,895.92	$20,894.74	$3,466.67	$297,257
Carroll	$32,291.01	$34,159.60	$0.00	$66,451
Carter	$19,421.05	$4,452.63	$0.00	$23,874
Cass	$31,790.52	$192,836.07	$1,666.67	$226,293
Cedar	$382,894.74	$5,606.03	$3,666.67	$392,167
Chariton	$8,880.19	$87,002.74	$0.00	$95,883
Christian	$544,631.58	$3,736.84	$22,000.00	$570,368
Clark	$33,293.36	$117,737.86	$0.00	$151,031
Clay	$116,280.58	$255,733.05	$0.00	$372,014
Clinton	$34,922.30	$24,328.91	$0.00	$59,251

County	Annualized Property Loss and Crop Claims-Wind ($)	Annualized Property Loss and Crop Claims-Hail ($)	Annualized Property Loss-Lightning ($)	Combined Annualized Losses (wind, hail, lightning) ($)
Cole	$60,873.68	$645.88	$2,333.33	$63,853
Cooper	$65,872.12	$8,942.88	$333.33	$75,148
Crawford	$10,226.32	$263.16	$0.00	$10,489
Dade	$95,736.84	$14,429.99	$3,666.67	$113,834
Dallas	$181,736.84	$6,131.58	$0.00	$187,868
Daviess	$34,801.97	$61,898.47	$333.33	$97,034
DeKalb	$80,247.75	$71,491.46	$0.00	$151,739
Dent	$67,357.89	$1,000.00	$0.00	$68,358
Douglas	$272,210.53	$20,394.74	$4,000.00	$296,605
Dunklin	$89,350.24	$19,366.88	$66.67	$108,784
Franklin	$44,933.30	$29,088.74	$0.00	$74,022
Gasconade	$62,715.79	$52,631.58	$8,386.67	$123,734
Gentry	$22,020.02	$456,309.67	$0.00	$478,330
Greene	$869,873.68	$41,300.00	$4,333.33	$915,507
Grundy	$28,562.74	$45,469.72	$0.00	$74,032
Harrison	$9,771.06	$66,505.44	$0.00	$76,277
Henry	$67,547.20	$3,430.63	$0.00	$70,978
Hickory	$8,612.33	$5,460.83	$0.00	$14,073
Holt	$61,071.68	$59,177.91	$0.00	$120,250
Howard	$19,723.01	$9,497.47	$0.00	$29,220
Howell	$224,210.53	$16,157.89	$4,266.67	$244,635
Iron	$52.63	$531.58	$0.00	$584
Jackson	$729,175.91	$832,258.75	$35,866.67	$1,597,301
Jasper	$300,149.20	$16,272.64	$38,666.67	$355,089
Jefferson	$9,563.16	$29,947.37	$3,466.67	$42,977
Johnson	$40,289.22	$6,379.31	$1,666.67	$48,335
Knox	$1,959.38	$12,579.66	$0.00	$14,539
Laclede	$86,315.79	$1,868.42	$36,300.00	$124,484
Lafayette	$76,422.78	$291,120.64	$0.00	$367,543
Lawrence	$274,347.57	$343,795.23	$0.00	$618,143
Lewis	$3,318.13	$8,014.73	$0.00	$11,333
Lincoln	$22,275.34	$4,170.22	$0.00	$26,446
Linn	$26,621.45	$84,872.62	$0.00	$111,494
Livingston	$34,963.55	$19,567.22	$0.00	$54,531
Macon	$17,168.02	$38,677.26	$0.00	$55,845
Madison	$13,184.21	$26.32	$0.00	$13,211

County	Annualized Property Loss and Crop Claims-Wind ($)	Annualized Property Loss and Crop Claims-Hail ($)	Annualized Property Loss-Lightning ($)	Combined Annualized Losses (wind, hail, lightning) ($)
Maries	$36,489.22	$263.16	$0.00	$36,752
Marion	$14,880.67	$63,244.45	$1,680.00	$79,805
McDonald	$37,842.11	$29,673.68	$666.67	$68,182
Mercer	$8,540.18	$17,161.70	$0.00	$25,702
Miller	$19,500.00	$2,789.47	$0.00	$22,289
Mississippi	$111,844.38	$24,394.82	$2,000.00	$138,239
Moniteau	$3,634.22	$526.32	$13,333.33	$17,494
Monroe	$4,082.01	$3,192.82	$0.00	$7,275
Montgomery	$8,365.99	$45,760.35	$0.00	$54,126
Morgan	$76,315.79	$12,750.10	$4,333.33	$93,399
New Madrid	$125,975.30	$42,878.76	$0.00	$168,854
Newton	$193,289.47	$19,669.60	$4,200.00	$217,159
Nodaway	$184,255.32	$1,188,432.57	$0.00	$1,372,688
Oregon	$61,052.63	$368.42	$0.00	$61,421
Osage	$4,023.16	$0.00	$0.00	$4,023
Ozark	$201,526.32	$5,315.79	$4,666.67	$211,509
Pemiscot	$92,156.83	$145,349.24	$0.00	$237,506
Perry	$2,704,921.05	$316,342.11	$66.67	$3,021,330
Pettis	$34,108.62	$125,617.94	$2,666.67	$162,393
Phelps	$58,742.11	$652.63	$13,666.67	$73,061
Pike	$11,050.93	$3,087.75	$666.67	$14,805
Platte	$57,528.82	$229,651.74	$6,666.67	$293,847
Polk	$407,447.37	$3,989.47	$0.00	$411,437
Pulaski	$15,289.47	$6,251.37	$0.00	$21,541
Putnam	$18,222.73	$520.88	$0.00	$18,744
Ralls	$6,168.68	$9,250.00	$0.00	$15,419
Randolph	$18,121.05	$325.28	$0.00	$18,446
Ray	$54,917.28	$22,601.78	$666.67	$78,186
Reynolds	$5,857.89	$2,631.58	$3,666.67	$12,156
Ripley	$78,472.51	$2,850.54	$0.00	$81,323
Saline	$100,050.47	$88,783.04	$0.00	$188,834
Schuyler	$11,780.68	$1,145.00	$0.00	$12,926
Scotland	$21,151.77	$200,770.32	$17,666.67	$239,589
Scott	$126,550.00	$50,200.08	$6,000.00	$182,750
Shannon	$167,684.21	$26.32	$0.00	$167,711
Shelby	$7,338.20	$15,864.50	$10,466.67	$33,669

County	Annualized Property Loss and Crop Claims-Wind ($)	Annualized Property Loss and Crop Claims-Hail ($)	Annualized Property Loss-Lightning ($)	Combined Annualized Losses (wind, hail, lightning) ($)
St. Charles	$139,533.93	$10,544,048.40	$1,000.00	$10,684,582
St. Clair	$20,473.68	$4,199.38	$1,200.00	$25,873
St. Francois	$23,494.74	$947.37	$6,666.67	$31,109
St. Louis	$29,689.45	$45,121,610.53	$18,000.00	$45,169,300
St. Louis City*	$32,578.95	$39,473.68	$333.33	72,386
Ste. Genevieve	$4,859.58	$207.84	$466.67	$5,534
Stoddard	$153,670.51	$128,928.39	$1,333.33	$283,932
Stone	$179,368.42	$11,652.63	$33,333.33	$224,354
Sullivan	$9,518.64	$1,264.27	$0.00	$10,783
Taney	$89,000.00	$29,215.79	$2,000.00	$120,216
Texas	$62,789.47	$12,610.53	$0.00	$75,400
Vernon	$34,263.16	$4,977.29	$1,200.00	$40,440
Warren	$6,417.20	$176.50	$0.00	$6,594
Washington	$26,526.32	$63.16	$0.00	$26,589
Wayne	$54,000.00	$8,947.37	$0.00	$62,947
Webster	$369,636.84	$2,321.05	$0.00	$371,958
Worth	$1,041.94	$10,269.88	$0.00	$11,312
Wright	$209,315.79	$42,236.84	$4,000.00	$255,553
Totals	$13,187,304.22	$63,232,281.99	$467,700.00	$76,887,286

Based on this data, Figure 3.5.6.5, Figure 3.5.6.6 and Figure 3.5.6.7 provide the potential annualized loss estimates for wind, lightning, and hail based on historical damages. Figure 3.5.6.8 at the conclusion of this section provides the combined total annualized losses to provide a total potential loss estimate for the severe thunderstorm hazard. There are no distinct patterns of loss that can be inferred from the maps other than higher losses in areas with greater exposure. Thus, this analysis demonstrates the random distribution of this hazard and its impacts around the State of Missouri.

Figure 3.5.6.5 - Annualized High Wind Damages (67 MPH or Greater)

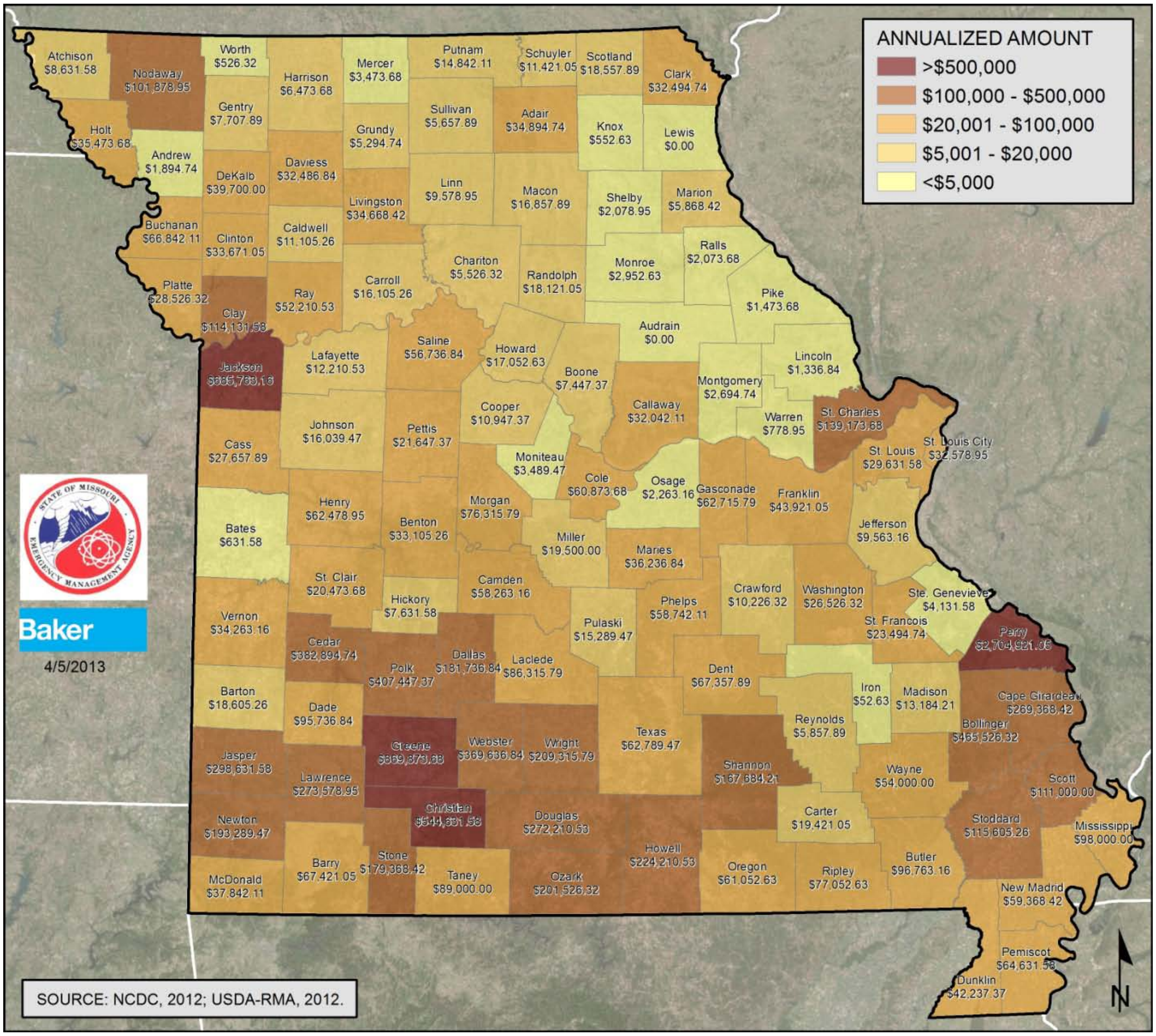


Figure 3.5.6.6 - Annualized Hail Damages (0.75 inches in Diameter or Larger)

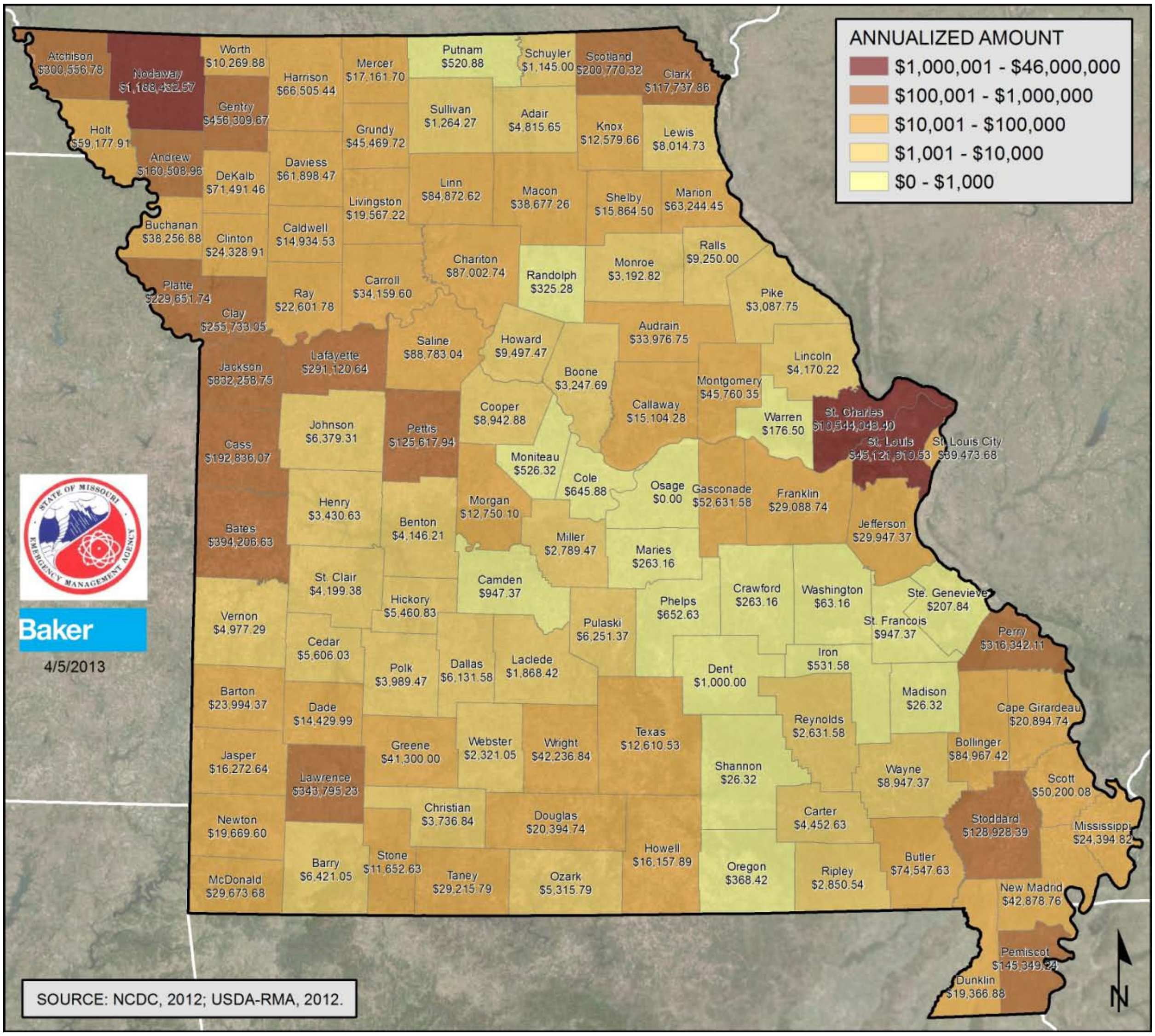


Figure 3.5.6.7 - Annualized Lightning Damages

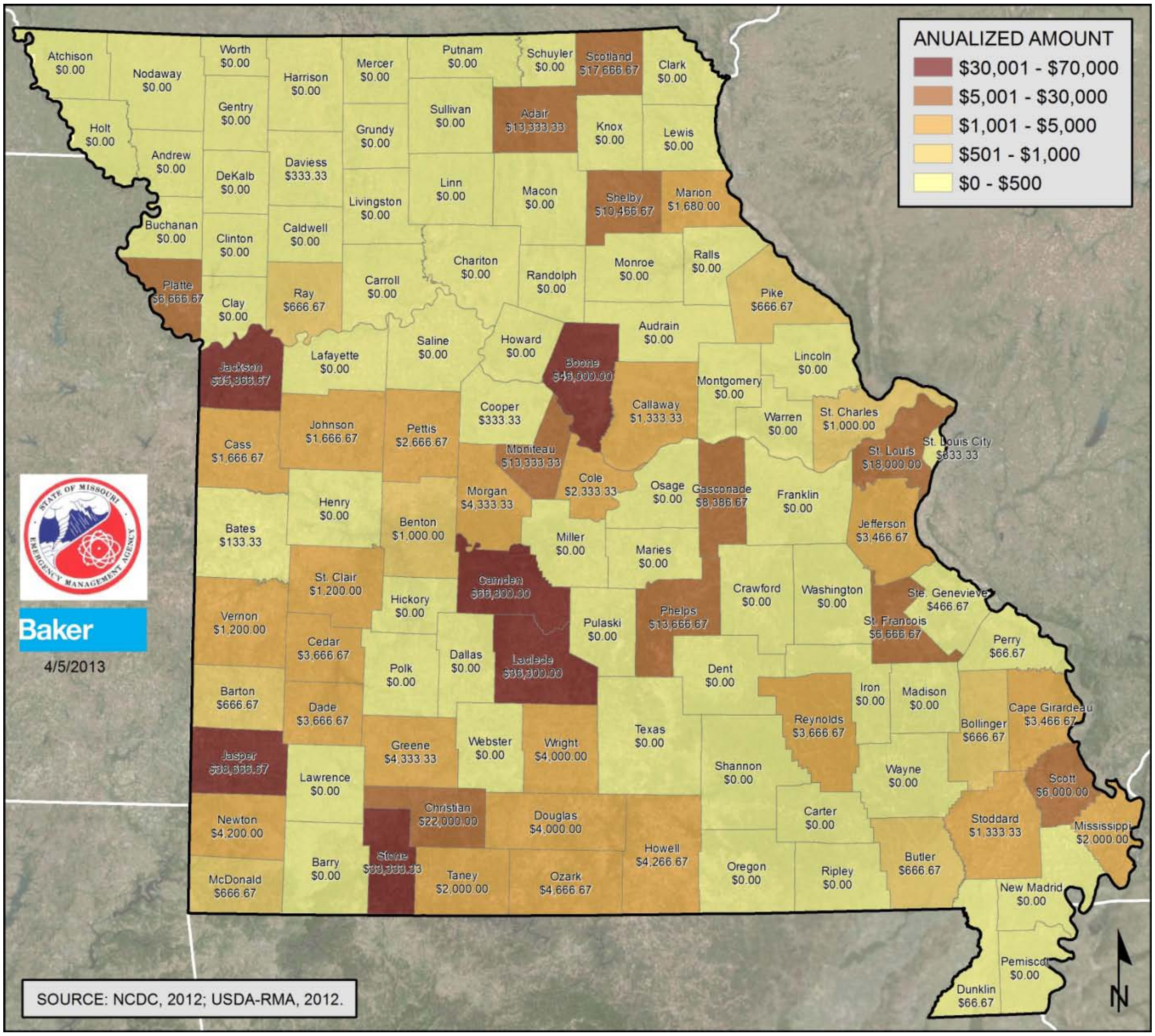
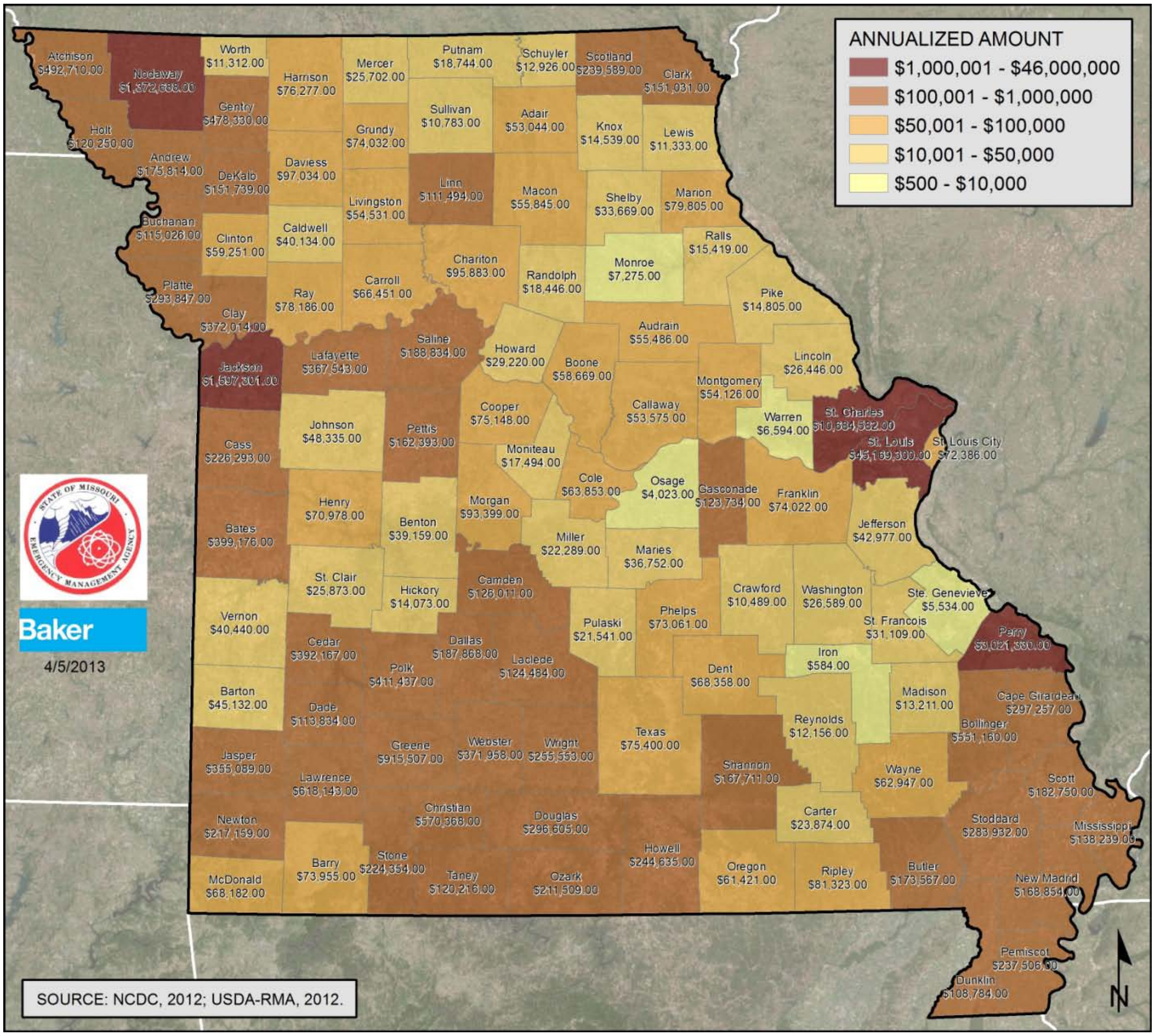


Figure 3.5.6.8 - Annualized Severe Thunderstorm Damages (Wind, Lightning, & Hail Combined)



Changes in Development for Jurisdictions in Hazard Prone Areas

Four counties rated "High" in overall vulnerability to Severe Thunderstorms; Boone, Greene, Jackson and St. Louis. Of these counties, only Boone County rated in the top ten in population gain in the 2010 census, at tenth. Boone County also rated eleventh in housing gain in the 2010 census returns. With growing population and increased development, there is potential for increased losses as a result of the increase in exposure. But, this will be dependent on where the severe thunderstorms occur which is a variable that cannot be predicted due to the random nature of this hazard

3.5.7 Tornadoes

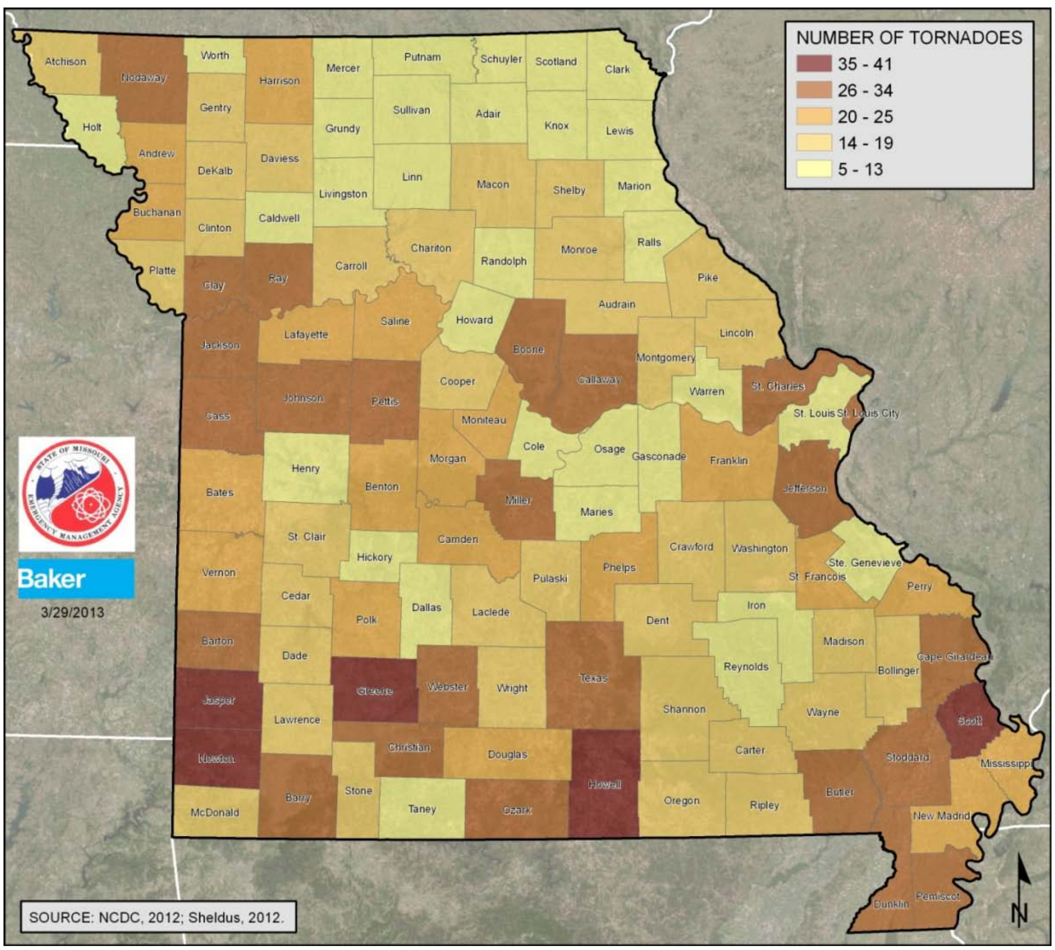
For hazard profile information for tornadoes, see Section 3.3.7.

Overview and Analysis of Vulnerability to Tornadoes

A statistical vulnerability methodology was used to determine annualized tornado losses by county. This methodology used the National Climatic Data Center data for tornado losses between 1950 and July 31, 2012. It is important to realize that one limitation to this data is that many tornadoes that might have occurred in uninhabited areas, as well as some in inhabited areas, may not have been reported. The incompleteness of the data suggests that it is not appropriate for use in parametric modeling. In addition, NOAA data cannot show a realistic frequency distribution of different Fujita scale tornado events, except for recent years. Thus a parametric model based on a combination of many physical aspects of the tornado to predict future expected losses was not used. The statistical model used for this analysis was probabilistic based purely on tornado frequency and historic losses. It is based on past experience and forecasts the expected results for the immediate or extended future.

The approach to the 2013 update of tornado risk in Missouri included an update of the tornado events and annualized losses and an enhanced analysis and representation of the risk assessment results. The number of tornado occurrences was updated by adding the events that have been reported in each county since July 31, 2009 (through July 31, 2012).

Figure 3.5.7.1 - Historical Number of Tornadoes in Missouri



In this update, the State looked at four factors to determine tornado vulnerability. This vulnerability analysis measured the likelihood of future tornado impacts, average annual property loss ratio (total building exposure value divided by average annualized historic losses), population change (percent change), and housing change (percent change). Scales were created to rank these factors: likelihood (1-3), loss ratio with exposure as of 2012 (1-3), population change from 2000 - 2010 (1-3), housing change from 2000-2010 (1-3). The factor scores were added up for each county for the purposes of ranking the counties by total vulnerability. This approach attempts to identify where tornadoes could have the greatest impacts. Devastating tornadoes could still impact counties that ranked lower in this process. For this reason, the low end of the risk is still considered Moderate and the top end Very High. Counties with a total risk score of 8 to 9 were considered to be at very high risk. Thirteen counties were identified as very high risk and are shown in red in Figure 3.5.7.2, are listed alphabetically below:

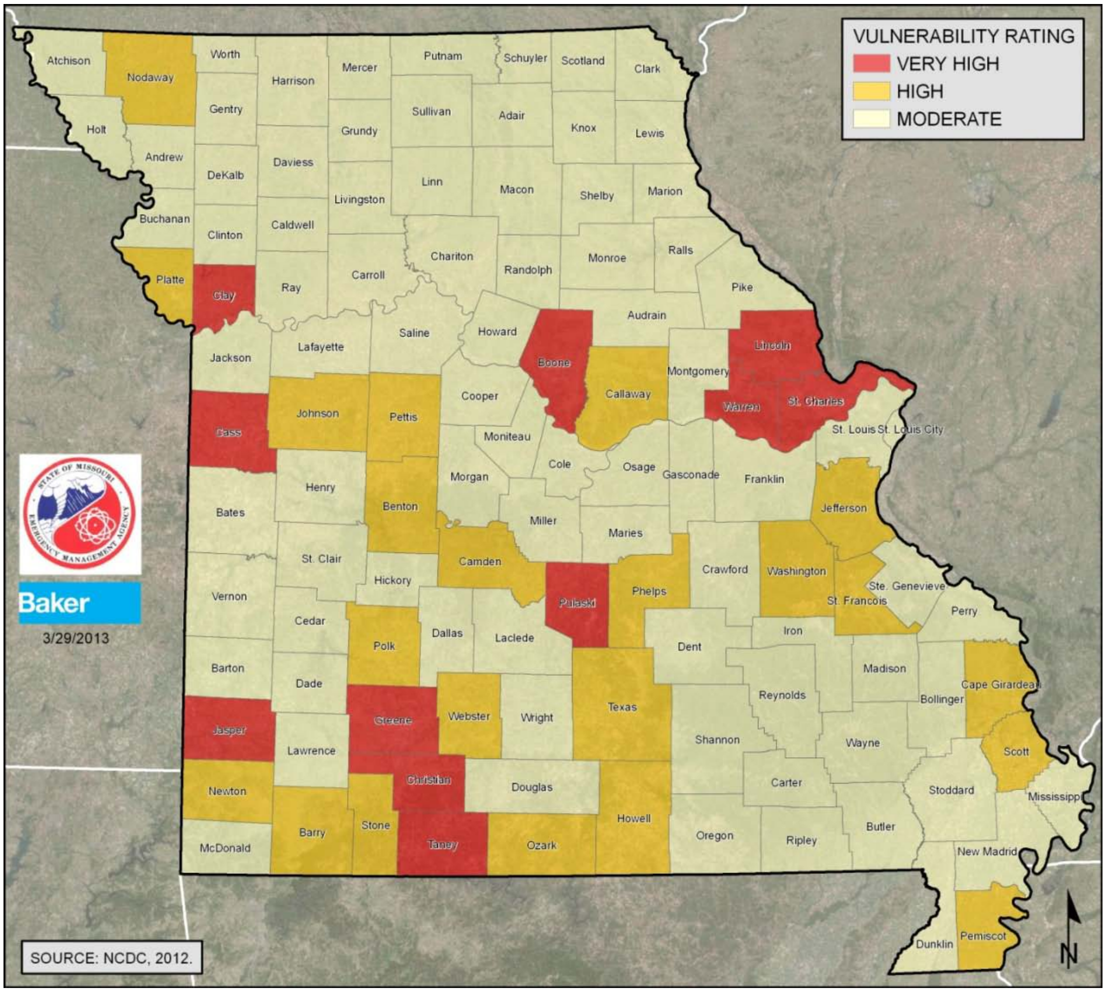
- Boone
- Cass
- Christian
- Greene
- Newton
- Ozark
- Pemiscot
- Platte
- Scott
- St. Charles
- Taney
- Warren
- Worth

The rating values of all factors were then combined to determine the overall vulnerability rating. Table 3.5.7a below provides the factors considered and the rating values assigned.

Table 3.5.7a Factors and Ranges Considered in Tornado Vulnerability Analysis

Factors Considered	Moderate (1)	High (2)	Very High (3)
Likelihood of Occurrence (# of events/ yrs. of data)	6-24	25-49	50-68
Loss Ratio %	0-.113	0.114-.226	0.227-0.340
Population % Change	Below 6	7-22	23-39
Housing % Change	Below 12	13-25	26-39
Overall Vulnerability Rating	4 and 5 Rating	6 and 7 Rating	3 and 9 Rating

Figure 3.5.7.2 - Vulnerability Summary for Tornadoes



While this approach attempts to prioritize tornado vulnerable counties, it does not identify any particular geographic patterns to tornado risk. This is consistent with the random nature of tornadoes. Additional analysis tables were created that list the 10 counties with the largest annualized historic tornado losses between 1950 and July 31, 2012 and the 13 counties with the greatest likelihood of being impacted by a tornado. These are shown in Table 3.5.7b and Table 3.5.7c respectively. Figure 3.5.7.3 shows a map of tornado probability by county (see Figure 3.5.7.4 for a map of Missouri tornadoes by county, 1950–July 31, 2012).

Table 3.5.7b Tornado Probability, Potential Loss, and Risk Summary

County	# of Tornadoes	Likelihood of Occurrence	Probability Rating	Total Exposure ($)	Annualized Historic Loss	Loss Ratio	Loss Ratio Rating	Population Growth % Change	Pop. Change Rating	Housing % Change	Housing Ratio Rating	Total Vulnerability
Adair	9	14.63%	1	$2,464,315,000	$87,579	0.004%	1	2.5%	1	2.15%	1	Moderate
Andrew	25	40.65%	2	$1,599,380,000	$196,653	0.012%	1	4.8%	1	6.81%	1	Moderate
Atchison	16	26.02%	2	$650,419,000	$84,322	0.013%	1	-11.6%	1	-8.23%	1	Moderate
Audrain	19	30.89%	2	$2,442,664,000	$167,527	0.007%	1	-1.3%	1	-2.58%	1	Moderate
Barry	31	50.41%	3	$3,161,148,000	$466,682	0.015%	1	4.7%	1	4.92%	1	High
Barton	29	47.15%	2	$1,301,748,000	$826,772	0.064%	1	-1.1%	1	0.69%	1	Moderate
Bates	22	35.77%	2	$1,598,983,000	$44,507	0.003%	1	2.4%	1	3.58%	1	Moderate
Benton	22	35.77%	2	$2,240,532,000	$191,788	0.009%	1	10.9%	1	13.87%	2	High
Bollinger	17	27.64%	2	$952,545,000	$27,737	0.003%	1	2.8%	1	5.92%	1	Moderate
Boone	32	52.03%	3	$17,363,239,000	$1,054,209	0.006%	1	20.1%	2	20.69%	2	Very High
Buchanan	21	34.15%	2	$9,701,152,000	$109,278	0.001%	1	3.7%	1	2.84%	1	Moderate
Butler	28	45.53%	2	$3,682,173,000	$429,128	0.012%	1	4.7%	1	5.36%	1	Moderate
Caldwell	8	13.01%	1	$942,135,000	$141,918	0.015%	1	5.1%	1	4.34%	1	Moderate
Callaway	30	48.78%	2	$4,134,300,000	$33,733	0.001%	1	8.7%	1	13.30%	2	High
Camden	22	35.77%	2	$7,136,339,000	$213,158	0.003%	1	18.8%	2	20.84%	2	High
Cape Girardeau	32	52.03%	3	$7,957,433,000	$149,113	0.002%	1	10.2%	1	10.63%	1	High
Carroll	16	26.02%	2	$1,066,261,000	$121,264	0.011%	1	-9.6%	1	-7.29%	1	Moderate
Carter	14	22.76%	1	$530,088,000	$459,016	0.087%	1	5.5%	1	7.61%	1	Moderate

County	# of Tornadoes	Likelihood of Occurrence	Probability Rating	Total Exposure ($)	Annualized Historic Loss	Loss Ratio	Loss Ratio Rating	Population Growth % Change	Pop. Change Rating	Housing % Change	Housing Ratio Rating	Total Vulnerability
Cass	33	53.66%	3	$10,245,424,000	$1,890,914	0.018%	1	21.2%	2	23.14%	2	Very High
Cedar	17	27.64%	2	$1,377,577,000	$1,015,269	0.074%	1	1.8%	1	2.69%	1	Moderate
Chariton	17	27.64%	2	$821,795,000	$239,312	0.029%	1	-7.2%	1	-6.54%	1	Moderate
Christian	27	43.90%	2	$6,354,341,000	$859,437	0.014%	1	42.6%	3	42.36%	3	Very High
Clark	13	21.14%	1	$614,995,000	$131,204	0.021%	1	-3.7%	1	-1.11%	1	Moderate
Clay	31	50.41%	3	$25,240,363,000	$556,062	0.002%	1	20.6%	2	20.20%	2	Very High
Clinton	19	30.89%	2	$2,143,758,000	$41,065	0.002%	1	9.3%	1	11.17%	1	Moderate
Cole	9	14.63%	1	$9,105,948,000	$297,012	0.003%	1	6.4%	1	9.92%	1	Moderate
Cooper	17	27.64%	2	$1,698,351,000	$47,042	0.003%	1	5.6%	1	10.49%	1	Moderate
Crawford	17	27.64%	2	$2,166,540,000	$1,569,054	0.072%	1	8.3%	1	10.98%	1	Moderate
Dade	17	27.64%	2	$712,879,000	$86,005	0.012%	1	-0.5%	1	2.15%	1	Moderate
Dallas	13	21.14%	1	$1,297,333,000	$62,608	0.005%	1	7.1%	1	8.19%	1	Moderate
Daviess	17	27.64%	2	$865,596,000	$86,896	0.010%	1	5.2%	1	1.13%	1	Moderate
DeKalb	18	29.27%	2	$891,756,000	$18,756	0.002%	1	11.2%	1	8.82%	1	Moderate
Dent	14	22.76%	1	$1,382,572,000	$36,661	0.003%	1	4.9%	1	5.95%	1	Moderate
Douglas	23	37.40%	2	$1,029,008,000	$191,956	0.019%	1	4.6%	1	7.42%	1	Moderate
Dunklin	29	47.15%	2	$2,492,777,000	$665,278	0.027%	1	-3.6%	1	-4.28%	1	Moderate
Franklin	21	34.15%	2	$10,276,147,000	$328,209	0.003%	1	8.2%	1	12.09%	1	Moderate
Gasconade	7	11.38%	1	$1,699,937,000	$1,132,245	0.067%	1	-0.8%	1	1.28%	1	Moderate
Gentry	18	29.27%	2	$646,605,000	$12,950	0.002%	1	-1.8%	1	-2.66%	1	Moderate

County	# of Tornadoes	Likelihood of Occurrence	Probability Rating	Total Exposure ($)	Annualized Historic Loss	Loss Ratio	Loss Ratio Rating	Population Growth % Change	Pop. Change Rating	Housing % Change	Housing Ratio Rating	Total Vulnerability
Greene	37	60.16%	3	$27,949,700,000	$2,305,620	0.008%	1	14.5%	2	16.74%	2	Very High
Grundy	10	16.26%	1	$1,023,068,000	15,179	0.001%	1	-1.6%	1	-4.06%	1	Moderate
Harrison	23	37.40%	2	$975,597,000	210,219	0.022%	1	1.2%	1	0.30%	1	Moderate
Henry	11	17.89%	1	$2,383,450,000	153,274	0.006%	1	1.3%	1	2.98%	1	Moderate
Hickory	12	19.51%	1	$898,778,000	41,518	0.005%	1	7.7%	1	11.76%	1	Moderate
Holt	8	13.01%	1	$591,854,000	4,943	0.001%	1	-8.2%	1	-4.65%	1	Moderate
Howard	9	14.63%	1	$1,010,144,000	22,203	0.002%	1	-0.7%	1	3.78%	1	Moderate
Howell	38	61.79%	3	$3,408,131,000	$1,200,223	0.035%	1	8.5%	1	9.69%	1	High
Iron	13	21.14%	1	$960,981,000	138,054	0.014%	1	-0.6%	1	4.31%	1	Moderate
Jackson	30	48.78%	2	$83,385,516,000	1,035,172	0.001%	1	2.9%	1	3.20%	1	Moderate
Jasper	41	66.67%	3	$10,870,600,000	48,523,987	0.446%	3	12.1%	2	10.21%	1	Very High
Jefferson	27	43.90%	2	$20,529,358,000	289,058	0.001%	1	10.3%	1	14.27%	2	High
Johnson	31	50.41%	3	$5,052,926,000	83,784	0.002%	1	9.0%	1	10.92%	1	High
Knox	8	13.01%	1	$398,969,000	26,902	0.007%	1	-5.3%	1	-4.63%	1	Moderate
Laclede	17	27.64%	2	$2,898,589,000	319,822	0.011%	1	9.4%	1	10.35%	1	Moderate
Lafayette	21	34.15%	2	$3,519,546,000	113,532	0.003%	1	1.3%	1	3.60%	1	Moderate
Lawrence	17	27.64%	2	$3,324,370,000	232,253	0.007%	1	9.7%	1	9.59%	1	Moderate
Lewis	12	19.51%	1	$899,056,000	76,301	0.008%	1	-2.7%	1	-2.07%	1	Moderate
Lincoln	16	26.02%	2	$4,340,031,000	89,265	0.002%	1	35.0%	3	36.50%	3	Very High
Linn	13	21.14%	1	$1,313,208,000	158,383	0.012%	1	-7.2%	1	-6.99%	1	Moderate

County	# of Tornadoes	Likelihood of Occurrence	Probability Rating	Total Exposure ($)	Annualized Historic Loss	Loss Ratio	Loss Ratio Rating	Population Growth % Change	Pop. Change Rating	Housing % Change	Housing Ratio Rating	Total Vulnerability
Livingston	11	17.89%	1	$1,385,494,000	$9,355	0.001%	1	4.4%	1	2.35%	1	Moderate
Macon	17	27.64%	2	$1,460,266,000	$285,637	0.020%	1	6.5%	1	3.59%	1	Moderate
Madison	19	30.89%	2	$1,091,078,000	$34,639	0.003%	1	-1.2%	1	-1.37%	1	Moderate
Maries	8	13.01%	1	$851,638,000	$94,100	0.011%	1	3.6%	1	3.97%	1	Moderate
Marion	12	19.51%	1	$2,789,835,000	$11,322	0.000%	1	3.1%	1	5.29%	1	Moderate
McDonald	17	27.64%	2	$1,498,071,000	$65,371	0.004%	1	1.7%	1	2.81%	1	Moderate
Mercer	13	21.14%	1	$367,552,000	$99,410	0.027%	1	0.7%	1	-2.50%	1	Moderate
Miller	29	47.15%	2	$2,194,585,000	$153,978	0.007%	1	5.0%	1	6.82%	1	Moderate
Mississippi	23	37.40%	2	$1,066,614,000	$639,739	0.060%	1	6.9%	1	-3.77%	1	Moderate
Moniteau	21	34.15%	2	$1,315,933,000	$883,498	0.067%	1	5.3%	1	5.19%	1	Moderate
Monroe	19	30.89%	2	$900,582,000	$2,955	0.000%	1	-5.1%	1	-0.49%	1	Moderate
Montgomery	16	26.02%	2	$1,254,588,000	$36,523	0.003%	1	0.8%	1	1.95%	1	Moderate
Morgan	22	35.77%	2	$2,518,783,000	$46,622	0.002%	1	6.5%	1	7.64%	1	Moderate
New Madrid	24	39.02%	2	$1,569,929,000	$656,763	0.042%	1	-4.1%	1	-1.05%	1	Moderate
Newton	39	63.41%	3	$5,027,857,000	$1,793,334	0.036%	1	10.4%	1	9.34%	1	High
Nodaway	31	50.41%	3	$2,097,395,000	$196,754	0.009%	1	6.7%	1	5.00%	1	High
Oregon	17	27.64%	2	$842,686,000	$294,461	0.035%	1	5.2%	1	6.19%	1	Moderate
Osage	10	16.26%	1	$1,427,835,000	$118,544	0.008%	1	6.3%	1	8.25%	1	Moderate
Ozark	29	47.15%	2	$784,866,000	$954,104	0.122%	2	1.9%	1	6.18%	1	High
Pemiscot	33	53.66%	3	$1,433,654,000	$1,038,572	0.072%	1	-8.7%	1	-6.43%	1	High

County	# of Tornadoes	Likelihood of Occurrence	Probability Rating	Total Exposure ($)	Annualized Historic Loss	Loss Ratio	Loss Ratio Rating	Population Growth % Change	Pop. Change Rating	Housing % Change	Housing Ratio Rating	Total Vulnerability
Perry	21	34.15%	2	$2,124,249,000	$1,172,592	0.055%	1	4.6%	1	6.56%	1	Moderate
Pettis	34	55.28%	3	$4,311,203,000	$2,031,696	0.047%	1	7.1%	1	5.52%	1	High
Phelps	23	37.40%	2	$4,283,040,000	$209,605	0.005%	1	13.4%	2	11.99%	1	High
Pike	17	27.64%	2	$1,732,955,000	$18,133	0.001%	1	0.9%	1	1.69%	1	Moderate
Platte	18	29.27%	2	$10,180,565,000	$711,023	0.007%	1	21.1%	2	23.31%	2	High
Polk	23	37.40%	2	$2,506,838,000	$221,638	0.009%	1	15.4%	2	17.75%	2	High
Pulaski	16	26.02%	2	$3,755,326,000	$1,876,552	0.050%	1	27.0%	3	19.14%	2	Very High
Putnam	9	14.63%	1	$493,213,000	$634	0.000%	1	-4.7%	1	-4.31%	1	Moderate
Ralls	9	14.63%	1	$1,036,049,000	$234,908	0.023%	1	5.6%	1	9.50%	1	Moderate
Randolph	8	13.01%	1	$2,337,954,000	$101,031	0.004%	1	3.0%	1	1.55%	1	Moderate
Ray	27	43.90%	2	$2,357,316,000	$394,267	0.017%	1	0.6%	1	2.45%	1	Moderate
Reynolds	11	17.89%	1	$717,542,000	$425,224	0.059%	1	0.1%	1	2.09%	1	Moderate
Ripley	17	27.64%	2	$1,050,116,000	$429,660	0.041%	1	4.4%	1	4.08%	1	Moderate
Saline	22	35.77%	2	$2,326,438,000	$431,128	0.019%	1	-1.6%	1	-1.46%	1	Moderate
Schuyler	8	13.01%	1	$369,094,000	$428,191	0.116%	2	6.3%	1	4.12%	1	Moderate
Scotland	10	16.26%	1	$475,226,000	$429,179	0.090%	1	-2.8%	1	-1.16%	1	Moderate
Scott	39	63.41%	3	$3,636,518,000	$433,502	0.012%	1	-3.0%	1	-0.56%	1	High
Shannon	14	22.76%	1	$725,557,000	$431,156	0.059%	1	1.4%	1	3.89%	1	Moderate
Shelby	16	26.02%	2	$677,622,000	$432,146	0.064%	1	-6.3%	1	-5.97%	1	Moderate
St. Charles	31	50.41%	3	$39,157,150,000	$433,134	0.001%	1	27.0%	3	32.08%	3	Very High

County	# of Tornadoes	Likelihood of Occurrence	Probability Rating	Total Exposure ($)	Annualized Historic Loss	Loss Ratio	Loss Ratio Rating	Population Growth % Change	Pop. Change Rating	Housing % Change	Housing Ratio Rating	Total Vulnerability
St. Clair	18	29.27%	2	$949,294,000	$434,260	0.046%	1	1.6%	1	3.00%	1	Moderate
St. Francois	20	32.52%	2	$6,073,289,000	$435,112	0.007%	1	17.5%	2	15.33%	2	High
St. Louis	29	47.15%	2	$127,497,738,000	$965,531	0.001%	1	-1.7%	1	0.11%	1	Moderate
St. Louis City*	5	8.13%	1	$41,414,257,000	$437,089	0.001%	1	-8.30%	1	-3.41%	1	Moderate
Ste. Genevieve	8	13.01%	1	$1,967,405,000	$438,077	0.022%	1	1.7%	1	6.89%	1	Moderate
Stoddard	30	48.78%	2	$2,589,294,000	$444,896	0.017%	1	0.9%	1	1.58%	1	Moderate
Stone	19	30.89%	2	$3,376,042,000	$597,039	0.018%	1	12.4%	2	15.80%	2	High
Sullivan	10	16.26%	1	$566,143,000	$441,224	0.078%	1	-7.0%	1	-6.32%	1	Moderate
Taney	12	19.51%	1	$4,708,947,000	$692,012	0.015%	1	30.2%	3	28.45%	3	Very High
Texas	27	43.90%	2	$2,059,876,000	$443,465	0.022%	1	13.1%	2	7.24%	1	High
Vernon	24	39.02%	2	$2,352,179,000	$444,010	0.019%	1	3.4%	1	5.40%	1	Moderate
Warren	9	14.63%	1	$3,105,665,000	$445,000	0.014%	1	32.6%	3	34.34%	3	Very High
Washington	18	29.27%	2	$1,678,841,000	$445,988	0.027%	1	7.9%	2	11.29%	1	High
Wayne	16	26.02%	2	$1,181,550,000	$460,465	0.039%	1	2.0%	1	2.99%	1	Moderate
Webster	29	47.15%	2	$2,628,891,000	$449,860	0.017%	1	16.6%	2	17.96%	2	High
Worth	12	19.51%	1	$248,027,000	$448,954	0.181%	2	-8.9%	1	-6.44%	1	Moderate
Wright	17	27.64%	2	$1,489,037,000	$449,943	0.030%	1	4.8%	1	5.90%	1	Moderate

Table 3.5.7c Top 10 Counties Ranked by Annualized Historic Tornado Loss 1950-July 2012

County	Annualized Historic Loss 1950-July 31, 2012
Jasper	$48,523,987
Greene	$2,305,620
Pettis	$2,031,696
Cass	$1,890,914
Pulaski	$1,876,552
Newton	$1,793,334
Crawford	$1,569,054
Perry	$1,172,592
Howell	$1,200,223
Gasconde	$1,132,245

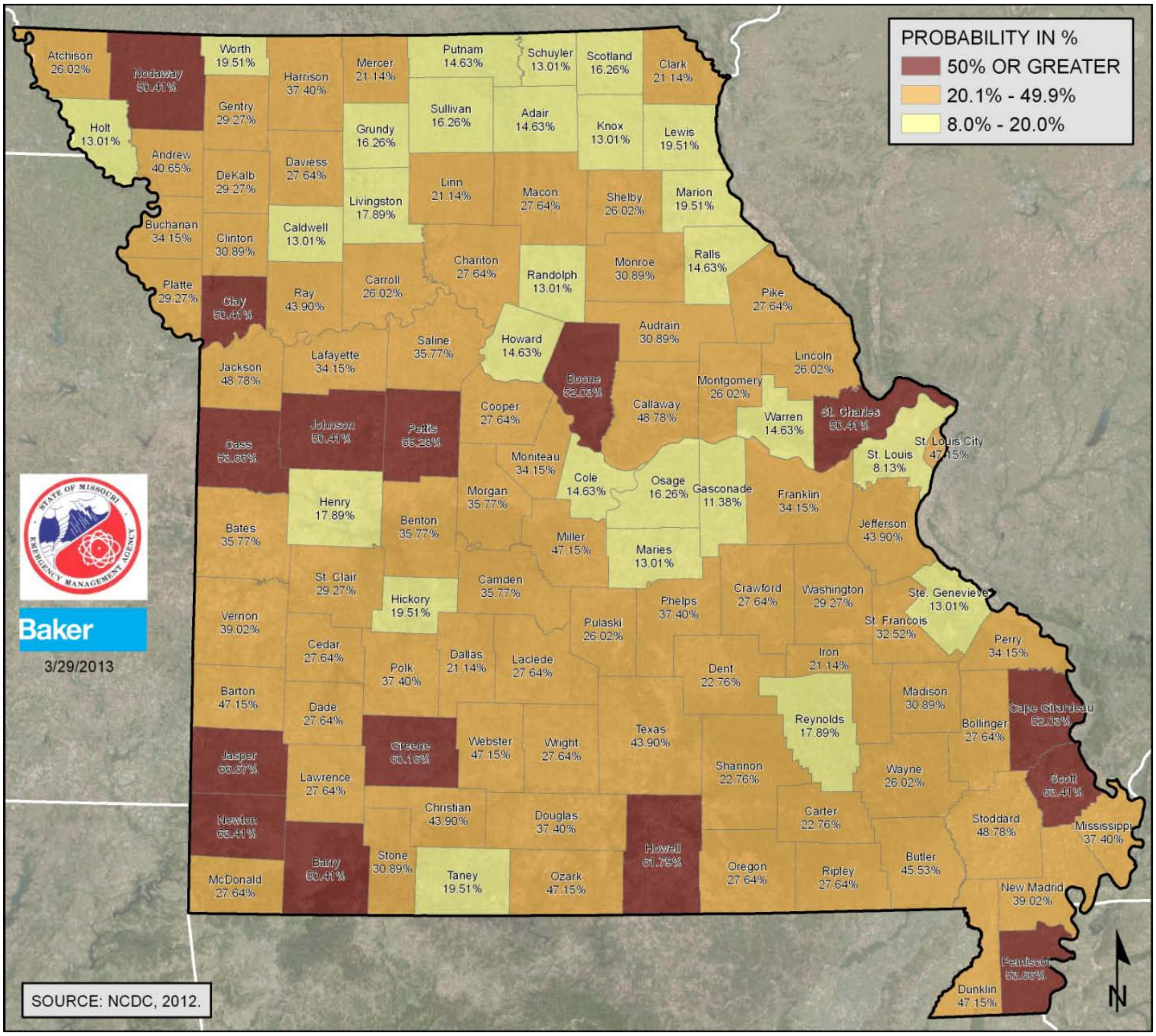
The top 13 Counties are in Table 3.5.7d since Cass, Clay, Jackson, and Johnson Counties all reported 30 tornadoes during this timeframe.

Table 3.5.7d Top 10 Counties Ranked by Number of Tornadoes/Likelihood of Occurrence 1950-July 31, 2012

County	# of Tornadoes 1950-July 31, 2012	Likelihood of Occurrence 1950- July 31, 2012
Jasper	41	66.67%
Newton	39	63.41%
Scott	39	63.41%
Howell	38	61.79%
Greene	37	60.16%
Pettis	34	55.28%
Pemiscot	33	53.66%
Cass	33	53.66%
Boone	32	52.03%
Cape Girardeau	32	52.03%

Figure 3.5.7.3 provides the likelihood probability of tornadoes in Missouri based on the historical events reported in the NCDC database from 1950 to July 31, 2012. There are 12 counties with greater than 50 percent probability of a tornado. Those include listed alphabetically are: Boone County, Cass County, Clay County, Greene County, Howell County, Jackson County, Jasper County, Johnson County, Newton County, Pemiscot County, Pettis County, and Scott County. This also shows the random nature with which tornadoes affect Missouri.

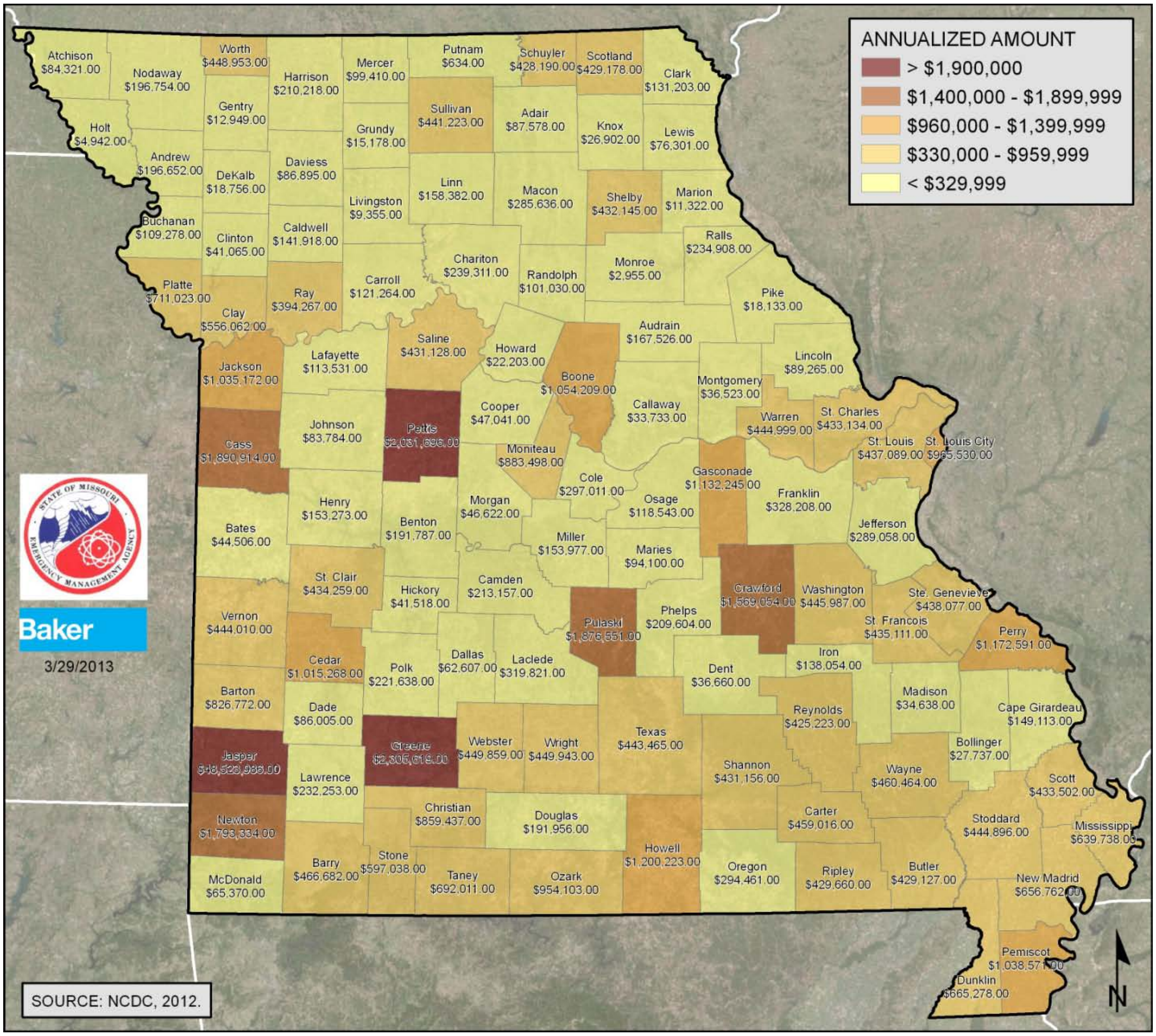
Figure 3.5.7.3 - Missouri Tornado Probability



Overview and Analysis of Potential Loss Estimates to Tornadoes

From this statistical data collected, annualized historical losses from 1950 to July 31, 2012 was considered in determining annualized tornado damages. See above Figure 3.5.7.3 for a by County list of historical losses.

Figure 3.5.7.4 - Annualized Tornado Damages



Changes in Development for Jurisdictions in Hazard Prone Areas

Due to the increase in population and growth and future development trends in Missouri, there will be increased vulnerability to tornadoes. Population and housing unit growth were factored into the previously described vulnerability analysis. The 11 counties with population increase that are also rated with very high tornado vulnerability are Boone, Cass, Christian, Greene, Newton, Platte, Scott, St. Charles, Taney, Warren, and Worth. Future development should consider tornadoes hazards at the planning, engineering, and architectural design stages.

3.5.8 Severe Winter Weather/Snow/Ice/Severe Cold

For hazard profile information for severe winter weather/snow/ice/severe cold, see Section 3.3.8.

Overview and Analysis of Vulnerability to Severe Winter Weather

Severe Winter Weather including snow, ice, and severe cold has caused more damage for Missourians in recent years with four Presidential Declarations since 2007.

The method used to determine vulnerability to severe winter weather across Missouri was statistical analysis of data from several sources: National Climatic Data Center (NCDC) storm events data (1993 to December 2012), FEMA's Public Assistance (PA) funds from DR-1672, DR-1736, DR-1748, DR-1822, and DR-1961, Crop Insurance Claims data from USDA's Risk Management Agency (1998-2012), total building exposure from HAZUS-MR4, U.S. Census Data (2000), and the USDA's Census of Agriculture (2007).

Table 3.5.8a provides the housing density, building exposure, crop exposure, total incidents, total property loss, and the total crop insurance paid. These are the common data elements for the analysis of severe winter weather. The total property loss column represents a combination of NCDC and FEMA PA funds. For declared events, the PA damage figures were used in lieu of NCDC data. NCDC damages represent early estimates and the FEMA PA funds represent actual expenditures.

Table 3.5.8a Housing Density, Building Exposure, Crop Exposure, Social Vulnerability Index, Total Incidents, Total Property Loss, and Total Crop Insurance Paid Data by County

County	Housing Units/sq. mi.	Total Building Exposure ($)	Crop Exposure (2007) ($)**	Total Incidents	Total $ Property Loss ($)	Total Crop Insurance Paid ($)
Adair	19.9	$2,464,315,000	$18,041,000	38	$15,504,477	$147,087
Andrew	16.9	$1,599,380,000	$40,516,000	37	$15,211,673	$130,240
Atchison	5.5	$650,419,000	$100,418,000	34	$14,982,061	$178,760
Audrain	15.7	$2,442,664,000	$89,405,000	43	$3,172,482	$517218
Barry	22.5	$3,161,148,000	$6,255,000	23	$14,154,080	$0
Barton	9.5	$1,301,748,000	$48,483,000	26	$5,766,950	$2,161,433
Bates	9.4	$1,598,983,000	$49,679,000	30	$32,151,000	$725,430
Benton	20.1	$2,240,532,000	$10,475,000	27	$5,227,471	$84,914
Bollinger	9.5	$952,545,000	$11,142,000	68	$10,498,531	$3,632
Boone	101.5	$17,363,239,000	$29,169,000	47	$4,940,103	$325,339
Buchanan	94.2	$9,701,152,000	$43,096,000	32	$6,695,048	$87,007
Butler	28.4	$3,682,173,000	$86,624,000	53	$13,090,241	$94,016
Caldwell	10.8	$942,135,000	$19,267,000	29	$5,651,309	$302,232
Callaway	22.2	$4,134,300,000	$29,405,000	39	$3,504,412	$342,049

County	Housing Units/sq. mi.	Total Building Exposure ($)	Crop Exposure (2007) ($)**	Total Incidents	Total $ Property Loss ($)	Total Crop Insurance Paid ($)
Camden	62.8	$7,136,339,000	$1,125,000	28	$7,394,963	$0
Cape Girardeau	56.4	$7,957,433,000	$45,460,000	58	$12,767,165	$54,932
Carroll	6.7	$1,066,261,000	$70,245,000	29	$32,750,000	$431,674
Carter	6.4	$530,088,000	$347,000	60	$10,278,332	$0
Cass	57.4	$10,245,424,000	$58,280,000	38	$32,150,000	$276,914
Cedar	15.2	$1,377,577,000	$3,899,000	25	$4,640,380	$14,123
Chariton	5.5	$821,795,000	$67,810,000	31	$33,150,000	$366,231
Christian	56.1	$6,354,341,000	$3,458,000	27	$14,169,329	$0
Clark	6.9	$614,995,000	$42,459,000	88	$2,435,000	$352,794
Clay	236.4	$25,240,363,000	$14,232,000	33	$37,300,000	$80,562
Clinton	21.2	$2,143,758,000	$32,487,000	34	$6,194,986	$186,204
Cole	82.1	$9,105,948,000	$8,405,000	37	$4,705,062	$3,535
Cooper	13.2	$1,698,351,000	$42,447,000	26	$32,650,000	$827,470
Crawford	16.1	$2,166,540,000	$1,777,000	38	$976,143	$0
Dade	8.1	$712,879,000	$19,641,000	25	$9,686,746	$438,507
Dallas	14.2	$1,297,333,000	$3,048,000	28	$8,161,081	$0
Daviess	7.5	$865,596,000	$37,669,000	42	$14,842,688	$151,618
DeKalb	10.3	$891,756,000	$26,390,000	37	$14,969,541	$291,749
Dent	9.7	$1,382,572,000	$1,270,000	24	$9,195,000	$0
Douglas	8	$1,029,008,000	$1,892,000	25	$9,459,318	$0
Dunklin	26.6	$2,492,777,000	$122,818,000	32	$33,329,915	$1,188,376
Franklin	47.1	$10,276,147,000	$24,032,000	42	$3,566,320	$15,422
Gasconade	15.8	$1,699,937,000	$8,075,000	43	$3,354,358	$8,583
Gentry	6.5	$646,605,000	$26,198,000	36	$14,929,637	$200,294
Greene	185.7	$27,949,700,000	$5,451,000	28	$75,501,585	$818
Grundy	11.5	$1,023,068,000	$31,071,000	38	$14,846,220	$168,922
Harrison	6.1	$975,597,000	$41,103,000	39	$14,870,963	$214,421
Henry	15.6	$2,383,450,000	$26,019,000	33	$32,155,000	$273,674
Hickory	17.1	$898,778,000	$1,948,000	25	$4,601,476	$15,937
Holt	6.1	$591,854,000	$74,872,000	28	$15,167,361	$129,023
Howard	9.9	$1,010,144,000	$34,407,000	22	$32,650,000	$23,013

County	Housing Units/sq. mi.	Total Building Exposure ($)	Crop Exposure (2007) ($)**	Total Incidents	Total $ Property Loss ($)	Total Crop Insurance Paid ($)
Howell	19.4	$3,408,131,000	$1,779,000	25	$15,560,788	$0
Iron	9.7	$960,981,000	$409,000	29	$5,000,000	$0
Jackson	516.3	$83,385,516,000	$27,724,000	50	$33,550,000	$100,103
Jasper	79.4	$10,870,600,000	$37,695,000	26	$15,254,841	$1661
Jefferson	133.4	$20,529,358,000	$5,554,000	29	$800,000	$0
Johnson	26	$5,052,926,000	$38,226,000	31	$32,155,000	$276,257
Knox	4.5	$398,969,000	$39,560,000	39	$2,400,000	$211,734
Laclede	20.6	$2,898,589,000	$3,754,000	27	$6,362,976	$0
Lafayette	23.4	$3,519,546,000	$85,068,000	33	$32,655,000	$2,356,514
Lawrence	27.2	$3,324,370,000	$17,378,000	28	$14,124,908	$205,798
Lewis	9	$899,056,000	$44,189,000	34	$2,400,000	$262,099
Lincoln	33.5	$4,340,031,000	$39,235,000	45	$3,582,660	$118,586
Linn	10.4	$1,313,208,000	$30,588,000	30	$6,200,000	$118,242
Livingston	12.6	$1,385,494,000	$47,535,000	33	$5,700,000	$541,850
Macon	9.6	$1,498,071,000	$31,574,000	28	$37,455,000	$28,641
Madison	12.1	$960,981,000	$708,000	27	$10,149,716	$0
Maries	8.7	$83,385,516,000	$2,394,000	24	$7,210,876	$339
Marion	29.4	$10,870,600,000	$49,252,000	42	$2,400,000	$192,597
McDonald	18.4	$20,529,358,000	$2,490,000	25	$7,166,394	$0
Mercer	4.7	$367,552,000	$14,186,000	37	$14,810,000	$162,465
Miller	21.5	$2,194,585,000	$3,820,000	20	$5,081,920	$0
Mississippi	13.9	$1,066,614,000	$104,434,000	44	$11,211,486	$333,586
Moniteau	39.5	$1,315,933,000	$17,069,000	38	$3,172,933	$172,195
Monroe	14.9	$900,582,000	$41,900,000	42	$2,400,000	$203,277
Montgomery	7.4	$1,254,588,000	$39,049,000	40	$3,203,263	$158,582
Morgan	11.4	$2,518,783,000	$11,237,000	24	$5,147,200	$36,406
New Madrid	26	$1,569,929,000	$141,223,000	47	$12,861,227	$656,522
Newton	12.6	$5,027,857,000	$10,906,000	27	$12,130,712	$44,636
Nodaway	38.9	$2,097,395,000	$88,341,000	36	$15,702,781	$103,642
Oregon	10.9	$842,686,000	$1,116,000	19	$14,757,690	$0
Osage	6.9	$1,427,835,000	$7,816,000	38	$2,973,496	$3,427

County	Housing Units/sq. mi.	Total Building Exposure ($)	Crop Exposure (2007) ($)**	Total Incidents	Total $ Property Loss ($)	Total Crop Insurance Paid ($)
Ozark	10.8	$784,866,000	$817,000	22	$9,480,051	$0
Pemiscot	7.6	$1,433,654,000	$100,096,000	31	$11,277,132	$812,563
Perry	16.6	$2,124,249,000	$25,608,000	70	$7,500,000	$31,218
Pettis	18.1	$4,311,203,000	$52,648,000	33	$32,650,000	$446,943
Phelps	26.7	$4,283,040,000	$1,510,000	25	$8,050,793	$23,993
Pike	29.1	$1,732,955,000	$49,657,000	38	$2,628,479	$240,921
Platte	11.7	$10,180,565,000	$43,973,000	39	$37,300,000	$85,450
Polk	20.9	$2,506,838,000	$6,054,000	28	$7,853,608	$11,053
Pulaski	32.7	$3,755,326,000	$948,000	23	$6,339,528	$0
Putnam	5.8	$493,213,000	$13,921,000	40	$14,922,753	$49,434
Ralls	11	$1,036,049,000	$42,557,000	43	$2,400,000	$70,534
Randolph	22.2	$2,337,954,000	$18,602,000	24	$32,650,000	$50,051
Ray	17.6	$2,357,316,000	$35,783,000	29	$37,055,000	$152,382
Reynolds	5	$717,542,000	$325,000	27	$10,114,630	$0
Ripley	10.5	$1,050,116,000	$6,640,000	52	$10,672,490	$29
Saline	13.4	$2,326,438,000	$116,807,000	26	$32,650,000	$421,785
Schuyler	6.8	$369,094,000	$6,584,000	41	$15,319,536	$67,391
Scotland	5.4	$475,226,000	$31,106,000	86	$2,455,691	$299,785
Scott	40.4	$3,636,518,000	$83,342,000	57	$13,491,359	$284,360
Shannon	4.1	$725,557,000	$636,000	23	$13,653,601	$0
Shelby	6.4	$677,622,000	$52,083,000	40	$2,400,000	$154,912
St. Charles	251.6	$39,157,150,000	$40,965,000	46	$5,096,930	$77,967
St. Clair	8.4	$949,294,000	$15,474,000	26	$5,796,038	$104,680
St. Francois	63	$6,073,289,000	$2,673,000	30	$5,300,000	$0
St. Louis	862.6	$41,414,257,000	$23,414,000	44	$4,131,840	$8,950
St. Louis City*	2842.9	$127,497,738,000	$0	41	$903,237	$0
Ste. Genevieve	17.3	$1,967,405,000	$12,265,000	29	$5,300,000	$24,927
Stoddard	16.5	$2,589,294,000	$166,828,000	52	$12,055,118	$1,100,368
Stone	43.9	$3,376,042,000	$1,789,000	24	$10,069,135	$0
Sullivan	5.2	$566,143,000	$13,041,000	35	$15,022,496	$87,513
Taney	46.3	$4,708,947,000	$790,000	20	$10,393,379	$0

County	Housing Units/sq. mi.	Total Building Exposure ($)	Crop Exposure (2007) ($)**	Total Incidents	Total $ Property Loss ($)	Total Crop Insurance Paid ($)
Texas	9.9	$2,059,876,000	$3,898,000	25	$9,657,209	$0
Vernon	11.5	$2,352,179,000	$39,281,000	26	$7,130,000	$1,297,557
Warren	34.3	$3,105,665,000	$18,134,000	44	$3,367,547	$132,678
Washington	14.5	$1,678,841,000	$711,000	33	$5,300,000	$0
Wayne	10.6	$1,181,550,000	$1,389,000	65	$10,326,267	$1,131
Webster	24.3	$2,628,891,000	$5,022,000	27	$11,190,062	$0
Worth	4.8	$248,027,000	$11,069,000	36	$15,408,583	$155,277
Wright	12.8	$1,489,037,000	$1,977,000	25	$11,031,775	$0

** The 2012 USDA Crop Census is being compiled in 2013 based on data collected from respondents. This data was not available at the time of publication of this plan.

From this statistical data collected, seven factors were considered in determining overall severe winter storm vulnerability as follows: housing density, likelihood of occurrence, building exposure, crop exposure, average annual property loss ratio, average annual crop insurance claims and social vulnerability.

To complete the vulnerability analysis utilizing the factors described above, a rating value of 1-5 was assigned to the data obtained for each factor. These rating values correspond to the following descriptive terms:

1) Low
2) Medium-low
3) Medium
4) Medium-high
5) High

The rating values of all factors were then combined to determine the overall vulnerability rating. Table 3.5.8b below provides the factors considered and the rating values assigned.

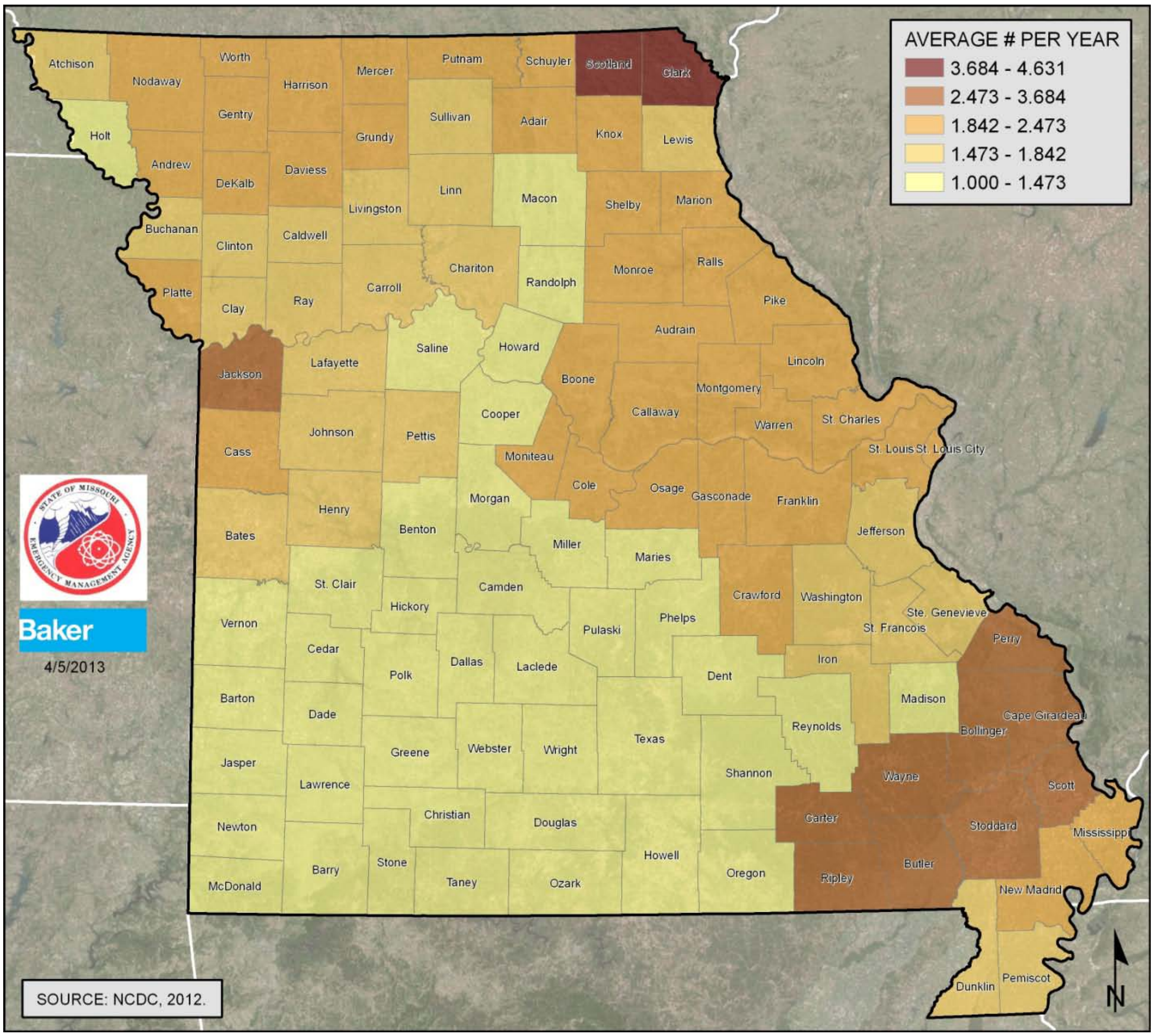
Table 3.5.8b Vulnerability Analysis Rating Factors

Factors Considered	Low (1)	Medium-low (2)	Medium (3)	Medium-high-4	High (5)
Housing Density (# per sq. mile)	<50	50 to 99	100 to 299	300 to 499	>500
Crop Exposure ($)	<$10M	$10M to $24M	$25M to $49M	$50M to $99M	>$100 M
Social Vulnerability	1	2	3	4	5
Likelihood of Occurrence (# of events/ yrs. of data)	1.000 – 1.473	1.473 – 1.842	1.842 – 2.473	2.473 – 3.684	3.684 – 4.631

Factors Considered	Low (1)	Medium-low (2)	Medium (3)	Medium-high-4	High (5)
Annualized Property Loss Ratio (annual property loss/ exposure)	0.0 – 0.000110	0.000111 – 0.000274	0.000275 – 0.000636	0.000637 – 0.001397	0.001398 – 0.003270

Figure 3.5.8.1 provides the likelihood of occurrence for severe winter weather events in Missouri counties based on the historical events reported in the NCDC database for the period from 1993 to July 2009.

Figure 3.5.8.1 - Likelihood of Occurrence of Severe Winter Weather



Once the ranges were determined and applied to all factors considered in the analysis for severe winter weather they were weighted equally and factored together to determine an overall vulnerability rating. Table 3.5.8b provides the calculated vulnerability rating for each factor considered in the vulnerability analysis for the severe winter weather hazard. Figure 3.5.8.2 that follows provides the mapped results of

this analysis by county. As seen, Dunklin, Worth, DeKalb, Gentry, Mercer, Mississippi, Pemiscot, Charlton, Grundy, Harrison, Schuyler, Scotland, Stoddard and New Madrid are all rated high in the vulnerability rating and they are located in the Northern portion of the state, as well as the bootheel of Missouri.

Table 3.5.8b Vulnerability Analysis for Severe Weather Hazard by County

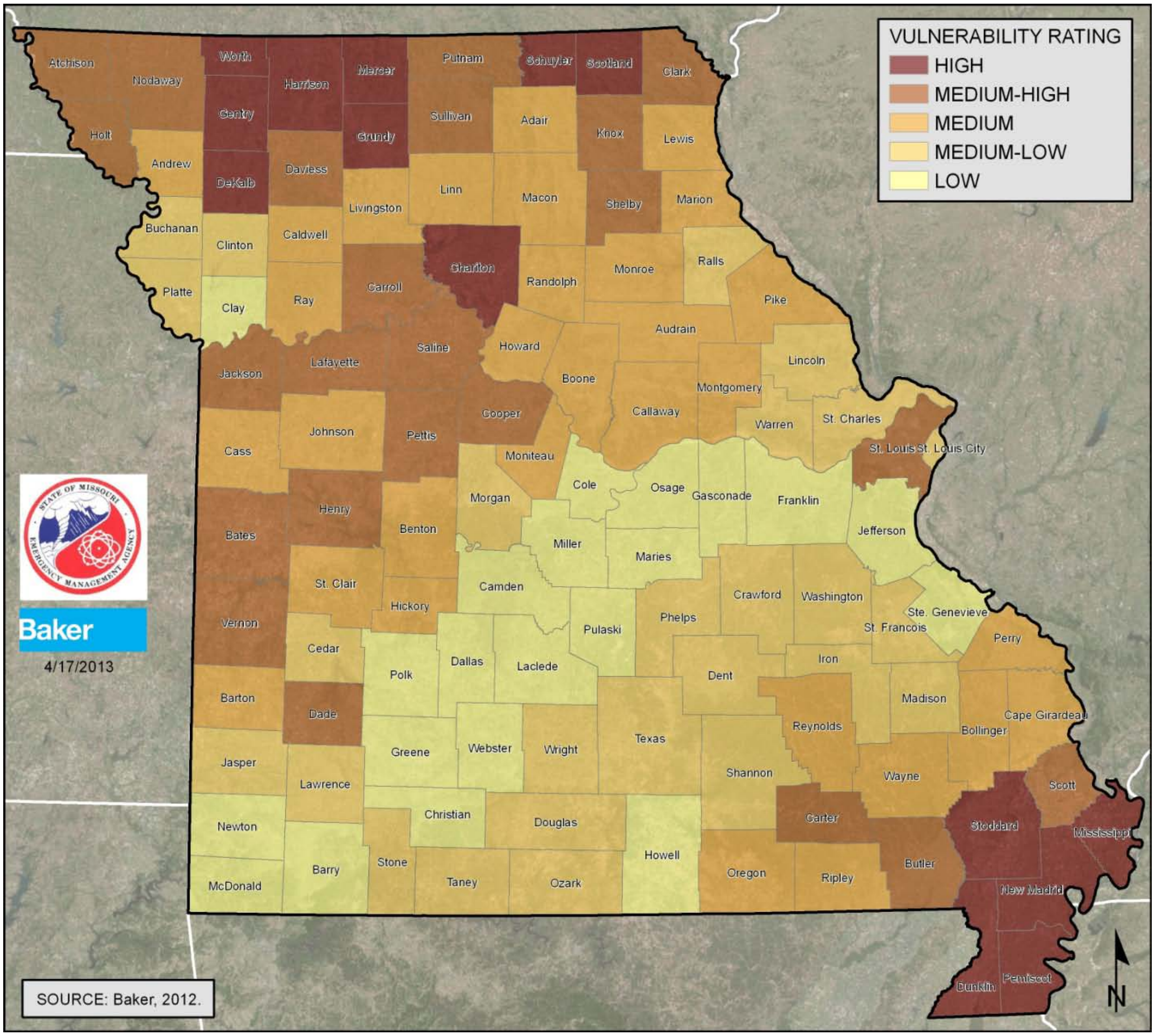
County	Housing Density Rating	Likelihood rating	Property Loss Ratio Rating	Crop Exposure Rating	Crop Loss Ratio Rating	Social Vulnerability Index	Total Score and Vulnerability	Vulnerability Rating
Adair	1	3	3	2	3	3	15	Medium
Andrew	1	3	3	3	2	1	13	Medium
Atchison	1	2	4	5	1	4	17	Medium-High
Audrain	1	3	1	4	2	3	14	Medium
Barry	1	1	2	1	1	3	9	Low
Barton	1	1	2	3	5	3	15	Medium
Bates	1	2	4	3	4	3	17	Medium-High
Benton	1	1	2	2	3	5	14	Medium
Bollinger	1	4	3	2	1	3	14	Medium
Boone	2	4	1	3	3	1	14	Medium
Buchanan	2	2	1	3	1	2	11	Medium-Low
Butler	1	4	2	4	1	4	16	Medium-High
Caldwell	1	2	3	2	4	3	15	Medium
Callaway	1	3	1	3	3	2	13	Medium
Camden	2	1	1	1	1	3	9	Low
Cape Girardeau	2	4	1	3	1	2	13	Medium
Carroll	1	2	5	4	2	3	17	Medium-High
Carter	1	4	4	1	1	5	16	Medium-High
Cass	2	3	2	4	2	1	14	Medium
Cedar	1	1	2	1	2	5	12	Medium-Low
Chariton	1	2	5	4	2	4	18	High
Christian	2	1	2	1	1	1	8	Low
Clark	1	5	2	3	3	3	17	Medium-High
Clay	3	1	1	2	2	1	10	Low
Clinton	1	2	2	3	2	2	12	Medium-Low

County	Housing Density Rating	Likelihood rating	Property Loss Ratio Rating	Crop Exposure Rating	Crop Loss Ratio Rating	Social Vulnerability Index	Total Score and Vulnerability	Vulnerability Rating
Cole	2	3	1	1	1	1	9	Low
Cooper	1	1	4	3	4	4	17	Medium-High
Crawford	1	3	1	1	1	4	11	Medium-Low
Dade	1	1	4	2	4	5	17	Medium-High
Dallas	1	1	3	1	1	3	10	Low
Daviess	1	3	4	3	2	3	16	Medium-High
DeKalb	1	3	4	3	3	5	19	High
Dent	1	1	3	1	1	4	11	Medium-Low
Douglas	1	1	3	1	1	4	11	Medium-Low
Dunklin	1	2	4	5	3	5	20	High
Franklin	2	3	1	2	1	1	10	Low
Gasconade	1	3	1	1	1	3	10	Low
Gentry	1	3	4	3	3	5	19	High
Greene	3	1	2	1	1	2	10	Low
Grundy	1	3	4	3	2	5	18	High
Harrison	1	3	4	3	2	5	18	High
Henry	1	2	4	3	3	4	17	Medium-High
Hickory	1	1	2	1	3	5	13	Medium
Holt	1	1	4	4	1	5	16	Medium-High
Howard	1	1	5	3	1	4	15	Medium
Howell	1	1	2	1	1	4	10	Low
Iron	1	2	2	1	1	5	12	Medium-Low
Jackson	4	4	1	3	2	2	16	Medium-High
Jasper	2	1	1	3	1	3	11	Medium-Low
Jefferson	2	2	1	1	1	1	8	Low
Johnson	1	2	3	3	3	2	14	Medium
Knox	1	3	3	3	2	5	17	Medium-High
Laclede	1	1	2	1	1	3	9	Low
Lafayette	1	2	3	4	5	2	17	Medium-High
Lawrence	1	1	2	2	3	3	12	Medium-Low
Lewis	1	2	2	3	2	4	14	Medium

County	Housing Density Rating	Likelihood rating	Property Loss Ratio Rating	Crop Exposure Rating	Crop Loss Ratio Rating	Social Vulnerability Index	Total Score and Vulnerability	Vulnerability Rating
Lincoln	1	3	1	3	2	1	11	Medium-Low
Linn	1	2	2	3	2	3	13	Medium
Livingston	1	2	2	3	3	3	14	Medium
Macon	1	1	4	3	1	4	14	Medium
Madison	1	1	3	1	1	4	11	Medium-Low
Maries	1	1	1	1	1	3	8	Low
Marion	1	3	1	3	2	4	14	Medium
McDonald	1	1	1	1	1	3	8	Low
Mercer	1	3	5	2	3	5	19	High
Miller	1	1	2	1	1	3	9	Low
Mississippi	1	3	3	5	2	5	19	High
Moniteau	1	3	2	2	3	3	14	Medium
Monroe	1	3	2	3	2	3	14	Medium
Montgomery	1	3	2	3	2	4	15	Medium
Morgan	1	1	1	2	2	4	11	Medium-Low
New Madrid	1	4	3	5	2	5	20	High
Newton	1	1	2	2	2	2	10	Low
Nodaway	1	3	3	4	1	4	16	Medium-High
Oregon	1	1	4	1	1	5	13	Medium
Osage	1	3	1	1	1	2	9	Low
Ozark	1	1	3	1	1	5	12	Medium-Low
Pemiscot	1	2	3	5	3	5	19	High
Perry	1	4	2	3	1	2	13	Medium
Pettis	1	2	3	4	3	3	16	Medium-High
Phelps	1	1	1	1	4	3	11	Medium-Low
Pike	1	3	1	3	2	4	14	Medium
Platte	1	3	2	3	1	1	11	Medium-Low
Polk	1	1	2	1	1	4	10	Low
Pulaski	1	1	1	1	1	3	8	Low
Putnam	1	3	5	2	2	4	17	Medium-High
Ralls	1	3	2	3	1	2	12	Medium-Low

County	Housing Density Rating	Likelihood rating	Property Loss Ratio Rating	Crop Exposure Rating	Crop Loss Ratio Rating	Social Vulnerability Index	Total Score and Vulnerability	Vulnerability Rating
Randolph	1	1	4	2	2	3	13	Medium
Ray	1	2	4	3	2	2	14	Medium
Reynolds	1	1	4	1	1	5	13	Medium
Ripley	1	4	3	1	1	5	15	Medium
Saline	1	1	4	5	2	4	17	Medium-High
Schuyler	1	3	5	1	3	5	18	High
Scotland	1	5	2	3	3	4	18	High
Scott	1	4	2	4	2	4	17	Medium-High
Shannon	1	1	4	1	1	4	12	Medium-Low
Shelby	1	3	2	4	2	4	16	Medium-High
St. Charles	3	3	1	3	1	1	12	Medium-Low
St. Clair	1	1	3	2	2	5	14	Medium
St. Francois	2	2	1	1	1	4	11	Medium-Low
St. Louis	4	3	1	2	1	5	16	Medium-High
St. Louis City*	5	3	1	1	1	1	12	Medium-Low
Ste. Genevieve	1	2	2	2	1	2	10	Low
Stoddard	1	4	2	5	2	4	18	High
Stone	2	1	2	1	1	4	11	Medium-Low
Sullivan	1	3	4	2	2	5	17	Medium-High
Taney	2	1	2	1	1	4	11	Medium-Low
Texas	1	1	2	1	1	5	11	Medium-Low
Vernon	1	1	2	3	5	5	17	Medium-High
Warren	1	3	1	2	3	1	11	Medium-Low
Washington	1	2	2	1	1	4	11	Medium-Low
Wayne	1	4	3	1	1	4	14	Medium
Webster	1	1	2	1	1	2	8	Low
Worth	1	3	5	2	4	5	20	High
Wright	1	1	3	1	1	4	11	Medium-Low

Figure 3.5.8.2 - Vulnerability Summary for Severe Winter Storm

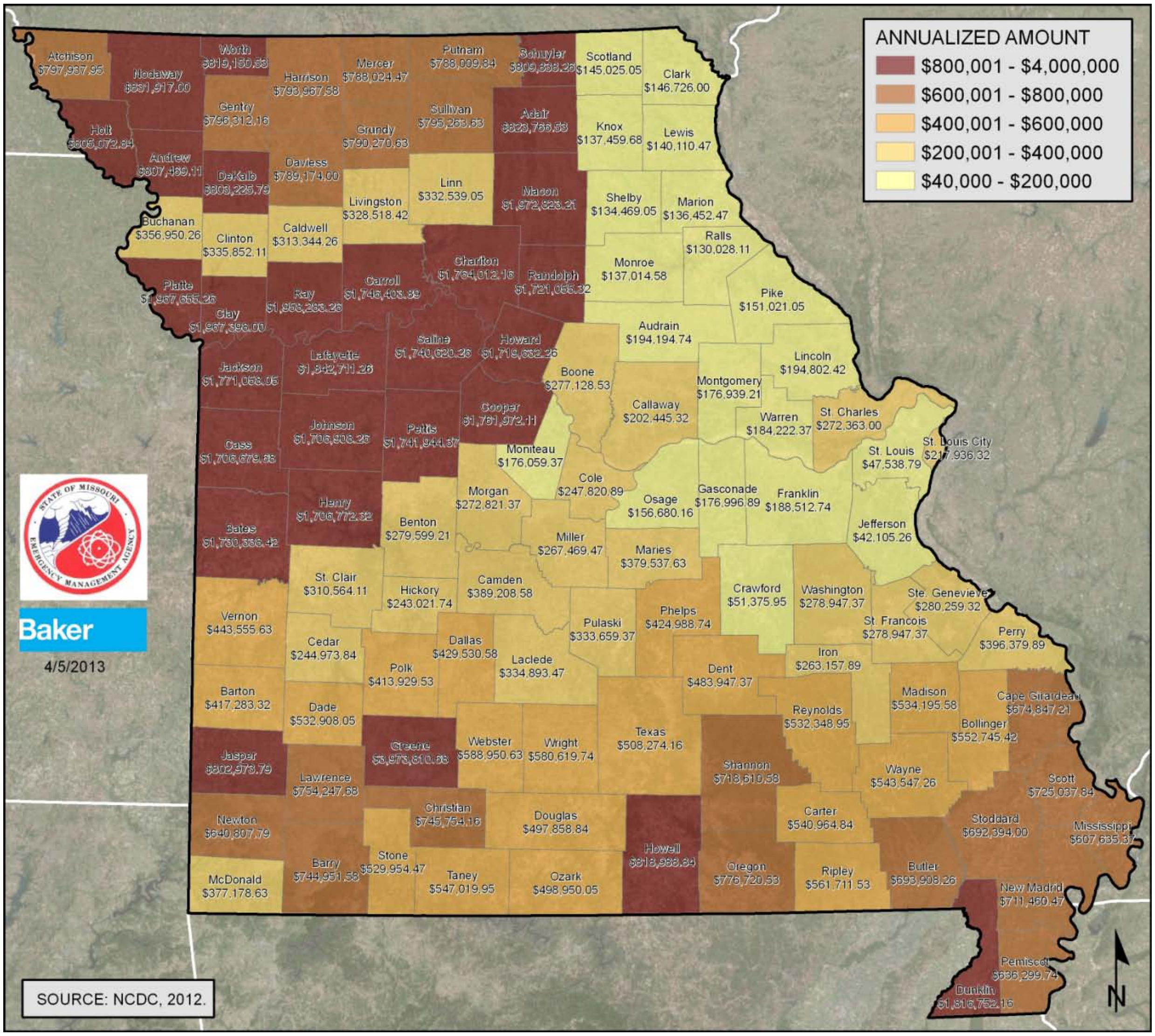


Overview and Analysis of Potential Loss Estimates to Severe Winter Weather

To determine potential loss estimates to severe winter weather in Missouri, the available historical loss data was annualized to determine future potential losses. Figure 3.5.9.2 provides the annualized total loss estimates (property and crop) for all counties in Missouri and the independent City of St. Louis. Most of the property damages that occur as a result of severe winter weather are a result of utility failure (loss of power). For additional information regarding vulnerability to utility failure, see Section 3.5.21.

Figure 3.5.8.3 shows the annualized severe winter weather damages across Missouri. Greene County has the highest annualized damages because of their Public Assistance claims from Winter Storm Disaster #1676 in January 2007.

Figure 3.5.8.3 - Annualized Severe Winter Weather Damages



Changes in Development for Jurisdictions in Hazard Prone Areas

In recent years, the weather pattern has caused more changes than development trend changes in Missouri. Many of the Presidential Declarations for winter weather have dealt with counties south of the Missouri River. However, in recent years winter storms have affected counties statewide. Also future development could potentially increase vulnerability to this hazard by increasing demand on the utilities and increasing the exposure of infrastructure networks.

According to the overall vulnerability summary for winter storms, the following counties have high vulnerability ratings: Dunklin, Worth, DeKalb, Gentry, Mercer, Mississippi, Pemiscot, Charlton, Grundy, Harrison, Schuyler, Scotland, Stoddard and New Madrid. Of these, only Schuyler County appears in the top ten counties for population growth and/or housing growth in the 2010 census.

3.5.9 Drought

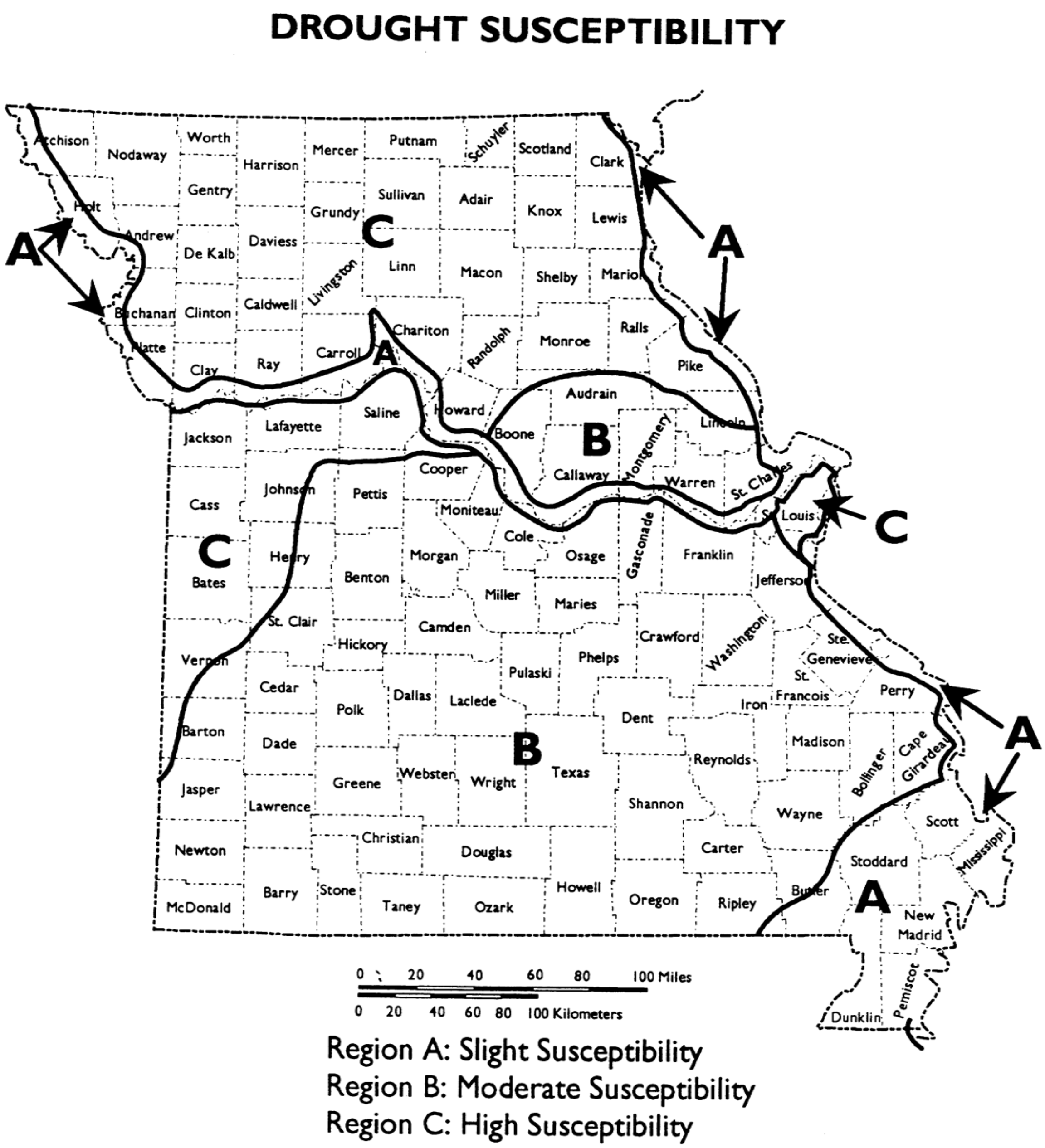
For profile information on drought, see Section 3.5.9.

Overview and Analysis of Vulnerability to Drought

The Missouri Drought Plan divides the State into three regions, which are prioritized according to drought susceptibility (see Figure 3.5.9.1). The regions are identified as having slight, moderate, and severe susceptibility to drought conditions. These regions differ from the six PDSI regions shown in Section 3.3.2 as the PDSI regions are geographically driven, instead of based on susceptibility like the regions illustrated in the Missouri Drought Plan. For example, Region A in the Missouri Drought Plan is mainly located in southeast Missouri, but also includes regions with similar drought susceptibility in the northwest and northeast portions of the state. Descriptions of drought susceptibility for the three regions from the Missouri Drought Plan are as follows:

- **Region A (mostly southeast Missouri)** has very little drought susceptibility. It is a region underlain by sands and gravel (alluvial deposits). Surface and groundwater resources are generally adequate for domestic, municipal, and agricultural needs.
- **Region B (central, east-central Missouri)** has moderate drought susceptibility. Groundwater resources are adequate to meet domestic and municipal water needs, but due to required well depths, irrigation wells are very expensive. The topography is generally unsuitable for row-crop irrigation.
- **Region C (northern, west-central Missouri; St. Louis County)** has severe drought vulnerability. Surface water sources usually become inadequate during extended drought. The groundwater resources are normally poor, and typically supply enough water only for domestic needs. Irrigation is generally not feasible. When irrigation is practical, groundwater withdrawal may affect other uses. Surface water sources are used to supplement irrigation supplied by groundwater sources (Hays, 1995).

Figure 3.5.9.1 - Drought Susceptibility



Source: Missouri Drought Plan, 2002

According to the Federal Emergency Management Agency (FEMA), drought costs the U.S. economy about $6 to 8 billion dollars a year. Losses from the severe 1988-1989 droughts totaled approximately $40 billion for 1988 (NCDC, 2012). The University of Missouri estimated the drought losses of 2002 and 2003 farm production years. Economic impact to the Missouri economy due to agricultural losses was about $461 million for 2002 (Cummings, 2012). Statistical data analysis was used to determine potential

losses for drought using the USDA Risk Management Agency's insured crop losses as a result of drought in conjunction with the USDA crop exposure by county. According to the USDA's Risk Management Agency 2011 Missouri Crop Insurance Profile, 81.2% of crops were insured that year (RMA/USDA, 2011). This data suggests that the majority of Missouri crops are insured. The Statistical data of crop insurance paid as a result of drought is from 1998-2012 and the USDA crop exposure by county is from 2007. Figure 3.5.9.2, below, shows the dark shaded counties are consistent with the Region B & C susceptibility counties shown above.

Figure 3.5.9.2 - Missouri Drought Crop Loss Ratio

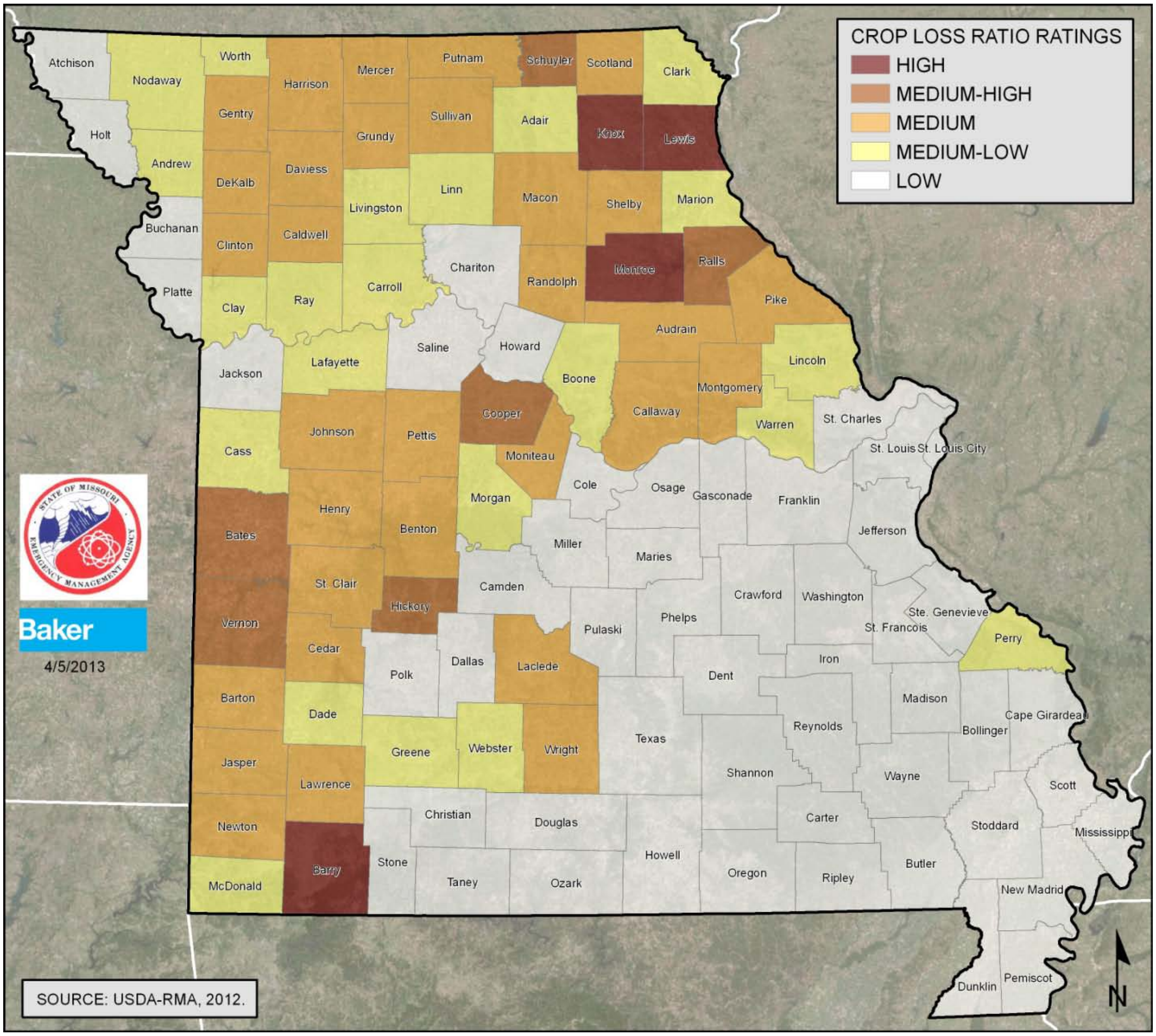


Table 3.5.9a Vulnerability of Missouri Counties to Drought (alphabetized)

County	Total Crop Insurance Paid for Drought Damage 1998-2012	Crop Claims Ratio Rating	Annualized Crop Insurance Claims/Drought Damage	Crop Exposure (2007 Census of Agriculture)	Annual Crop Claims Ratio	Crop Loss Ratio Rating
Adair	$9,515,268	2	$634,351	$18,041,000	3.52%	2
Andrew	$18,150,174	2	$1,210,012	$40,516,000	2.99%	2
Atchison	$28,646,875	3	$1,909,792	$100,418,000	1.90%	1
Audrain	$74,997,056	5	$4,999,804	$89,405,000	5.59%	3
Barry	$9,958,278	2	$663,885	$6,255,000	10.61%	5
Barton	$40,513,909	4	$2,700,927	$48,483,000	5.57%	3
Bates	$49,475,429	4	$3,298,362	$49,679,000	6.64%	4
Benton	$9,342,978	2	$622,865	$10,475,000	5.95%	3
Bollinger	$2,045,800	1	$136,387	$11,142,000	1.22%	1
Boone	$12,258,483	2	$817,232	$29,169,000	2.80%	2
Buchanan	$7,893,030	2	$526,202	$43,096,000	1.22%	1
Butler	$581,605	1	$38,774	$86,624,000	0.04%	1
Caldwell	$17,270,939	2	$1,151,396	$19,267,000	5.98%	3
Callaway	$20,726,613	2	$1,381,774	$29,405,000	4.70%	3
Camden	$206,980	1	$13,799	$1,125,000	1.23%	1
Cape Girardeau	$9,451,603	2	$630,107	$45,460,000	1.39%	1
Carroll	$22,820,025	3	$1,521,335	$70,245,000	2.17%	2
Carter	$0	1	$0	$347,000	0.00%	1
Cass	$22,830,416	3	$1,522,028	$58,280,000	2.61%	2
Cedar	$2,598,304	1	$173,220	$3,899,000	4.44%	3
Chariton	$17,766,646	2	$1,184,443	$67,810,000	1.75%	1
Christian	$754,685	1	$50,312	$3,458,000	1.45%	1
Clark	$23,807,346	3	$1,587,156	$42,459,000	3.74%	2
Clay	$5,512,652	1	$367,510	$14,232,000	2.58%	2
Clinton	$26,930,631	3	$1,795,375	$32,487,000	5.53%	3
Cole	$1,296,987	1	$86,466	$8,405,000	1.03%	1
Cooper	$39,925,217	4	$2,661,681	$42,447,000	6.27%	4
Crawford	$241,833	1	$16,122	$1,777,000	0.91%	1
Dade	$7,019,964	1	$467,998	$19,641,000	2.38%	2
Dallas	$674,200	1	$44,947	$3,048,000	1.47%	1
Daviess	$24,588,358	3	$1,639,224	$37,669,000	4.35%	3
DeKalb	$22,983,620	3	$1,532,241	$26,390,000	5.81%	3
Dent	$1,949	1	$130	$1,270,000	0.01%	1
Douglas	$9,346	1	$623	$1,892,000	0.03%	1
Dunklin	$3,581,362	1	$238,757	$122,818,000	0.19%	1
Franklin	$4,562,231	1	$304,149	$24,032,000	1.27%	1
Gasconade	$2,096,490	1	$139,766	$8,075,000	1.73%	1
Gentry	$23,264,303	3	$1,550,954	$26,198,000	5.92%	3
Greene	$2,298,160	1	$153,211	$5,451,000	2.81%	2
Grundy	$18,901,080	2	$1,260,072	$31,071,000	4.06%	3
Harrison	$33,044,752	3	$2,202,983	$41,103,000	5.36%	3
Henry	$21,403,194	2	$1,426,880	$26,019,000	5.48%	3
Hickory	$1,933,434	1	$128,896	$1,948,000	6.62%	4
Holt	$13,659,077	2	$910,605	$74,872,000	1.22%	1
Howard	$6,047,383	1	$403,159	$34,407,000	1.17%	1

County	Total Crop Insurance Paid for Drought Damage 1998-2012	Crop Claims Ratio Rating	Annualized Crop Insurance Claims/Drought Damage	Crop Exposure (2007 Census of Agriculture)	Annual Crop Claims Ratio	Crop Loss Ratio Rating
Howell	$0	1	$0	$1,779,000	0.00%	1
Iron	$0	1	$0	$409,000	0.00%	1
Jackson	$6,748,129	1	$449,875	$27,724,000	1.62%	1
Jasper	$23,436,084	3	$1,562,406	$37,695,000	4.14%	3
Jefferson	$566,323	1	$37,755	$5,554,000	0.68%	1
Johnson	$26,960,713	3	$1,797,381	$38,226,000	4.70%	3
Knox	$48,197,545	4	$3,213,170	$39,560,000	8.12%	5
Laclede	$2,605,055	1	$173,670	$3,754,000	4.63%	3
Lafayette	$28,216,648	3	$1,881,110	$85,068,000	2.21%	2
Lawrence	$11,813,173	2	$787,545	$17,378,000	4.53%	3
Lewis	$55,150,020	5	$3,676,668	$44,189,000	8.32%	5
Lincoln	$18,973,799	2	$1,264,920	$39,235,000	3.22%	2
Linn	$17,712,343	2	$1,180,823	$30,588,000	3.86%	2
Livingston	$19,412,211	2	$1,294,147	$47,535,000	2.72%	2
Macon	$24,791,482	3	$1,652,765	$31,574,000	5.23%	3
Madison	$129,042	1	$8,603	$708,000	1.22%	1
Maries	$518,487	1	$34,566	$2,394,000	1.44%	1
Marion	$29,028,378	3	$1,935,225	$49,252,000	3.93%	2
McDonald	$1,438,925	1	$95,928	$2,490,000	3.85%	2
Mercer	$10,534,998	2	$702,333	$14,186,000	4.95%	3
Miller	$535,786	1	$35,719	$3,820,000	0.94%	1
Mississippi	$2,475,577	1	$165,038	$104,434,000	0.16%	1
Moniteau	$11,534,745	2	$768,983	$17,069,000	4.51%	3
Monroe	$55,129,594	5	$3,675,306	$41,900,000	8.77%	5
Montgomery	$27,336,579	3	$1,822,439	$39,049,000	4.67%	3
Morgan	$6,669,513	1	$444,634	$11,237,000	3.96%	2
New Madrid	$2,726,779	1	$181,785	$141,223,000	0.13%	1
Newton	$8,587,124	2	$572,475	$10,906,000	5.25%	3
Nodaway	$32,370,284	3	$2,158,019	$88,341,000	2.44%	2
Oregon	$0	1	$0	$1,116,000	0.00%	1
Osage	$1,386,852	1	$92,457	$7,816,000	1.18%	1
Ozark	$0	1	$0	$817,000	0.00%	1
Pemiscot	$9,357,597	2	$623,840	$100,096,000	0.62%	1
Perry	$7,972,748	2	$531,517	$25,608,000	2.08%	2
Pettis	$44,470,557	4	$2,964,704	$52,648,000	5.63%	3
Phelps	$4,352	1	$290	$1,510,000	0.02%	1
Pike	$42,282,993	4	$2,818,866	$49,657,000	5.68%	3
Platte	$9,137,224	2	$609,148	$43,973,000	1.39%	1
Polk	$1,277,110	1	$85,141	$6,054,000	1.41%	1
Pulaski	$140,664	1	$9,378	$948,000	0.99%	1
Putnam	$9,889,583	2	$659,306	$13,921,000	4.74%	3
Ralls	$40,336,115	4	$2,689,074	$42,557,000	6.32%	4
Randolph	$11,968,733	2	$797,916	$18,602,000	4.29%	3
Ray	$12,036,449	2	$802,430	$35,783,000	2.24%	2
Reynolds	$0	1	$0	$325,000	0.00%	1
Ripley	$131,485	1	$8,766	$6,640,000	0.13%	1
Saline	$34,881,704	3	$2,325,447	$116,807,000	1.99%	1
Schuyler	$7,487,970	1	$499,198	$6,584,000	7.58%	4

County	Total Crop Insurance Paid for Drought Damage 1998-2012	Crop Claims Ratio Rating	Annualized Crop Insurance Claims/Drought Damage	Crop Exposure (2007 Census of Agriculture)	Annual Crop Claims Ratio	Crop Loss Ratio Rating
Scotland	$25,096,242	3	$1,673,083	$31,106,000	5.38%	3
Scott	$2,940,844	1	$196,056	$83,342,000	0.24%	1
Shannon	$0	1	$0	$636,000	0.00%	1
Shelby	$34,874,059	3	$2,324,937	$52,083,000	4.46%	3
St. Charles	$8,654,830	2	$576,989	$40,965,000	1.41%	1
St. Clair	$11,495,789	2	$766,386	$15,474,000	4.95%	3
St. Francois	$455,176	1	$30,345	$2,673,000	1.14%	1
St. Louis	$781,024	1	$52,068	$23,414,000	0.22%	1
St. Louis City*	$0	1	$0	$0	-	1
Ste. Genevieve	$3,164,185	1	$210,946	$12,265,000	1.72%	1
Stoddard	$6,178,463	1	$411,898	$166,828,000	0.25%	1
Stone	$155,624	1	$10,375	$1,789,000	0.58%	1
Sullivan	$10,115,203	2	$674,347	$13,041,000	5.17%	3
Taney	$0	1	$0	$790,000	0.00%	1
Texas	$0	1	$0	$3,898,000	0.00%	1
Vernon	$42,120,847	4	$2,808,056	$39,281,000	7.15%	4
Warren	$7,775,485	2	$518,366	$18,134,000	2.86%	2
Washington	$0	1	$0	$711,000	0.00%	1
Wayne	$152,009	1	$10,134	$1,389,000	0.73%	1
Webster	$2,308,781	1	$153,919	$5,022,000	3.06%	2
Worth	$5,437,082	1	$362,472	$11,069,000	3.27%	2
Wright	$1,263,512	1	$84,234	$1,977,000	4.26%	3

Source: USDA Risk Management Agency and USDA crop exposure

After compiling historical statistics, and computing to determine the factor values for each county, each factor was divided into 5 ranges with 5 being the highest and 1 being the lowest. Table 3.5.9b, below, provides the ranges that were applied to each factor.

Table 3.5.9b Ranges for Drought Vulnerability Factor Ratings

Factors Considered	Low (1)	Medium-low (2)	Medium (3)	Medium-high-4	High (5)
Crop Loss Ratio Rating	0 – 2 %	2 – 4 %	4 – 6 %	6 – 8 %	> 8 %
Annualized Claims Paid	< $500,000	$500,000-$1.5 M	$1.5 M-$2.5 M	$2.5M-$3.5 M	> $3.5 M

According to this analysis, the counties with a high or medium-high vulnerability to crop loss as a result of drought are: Audrain, Barry, Barton, Bates, Cooper, Hickory, Knox, Lewis, Monroe, Pettis, Ralls, Schuyler, and Vernon Counties.

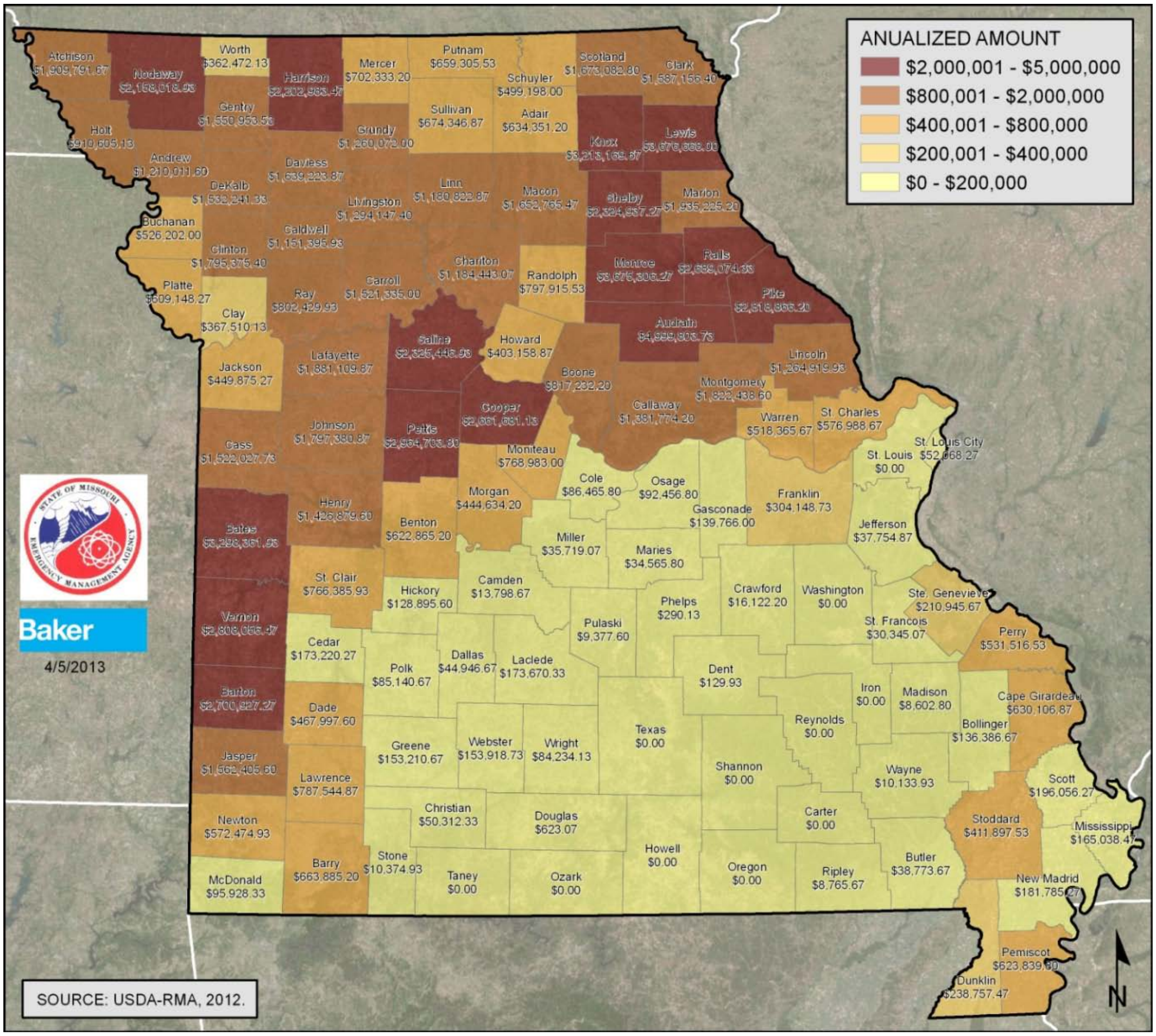
Overview and Analysis of Potential Loss Estimates to Drought

Determining the direct and indirect costs associated with drought is difficult because of the broad impacts of drought and the difficulty in establishing when droughts begin and end. This may be more accurately documented in local mitigation plans and direct costs associated with droughts.

The drought loss estimation methodology uses USDA Risk Management Agency's crop insurance claims paid in Missouri from 1998-2012 and the USDA's crop exposure value by county to determine the Annualized Drought Crop Insurance Claims Paid as mapped in Figure 3.5.9.3 below. USDA Risk Management Agency's crop insurance claims paid as a result of drought conditions during this time period totaled $1,530,919,292. This results in a statewide annualized amount of $102,061,286. This data is provided for all Missouri counties in Table 3.5.9a above. Crop insurance claims data was obtained for all hazards that resulted in payment of claims. Of all hazards that generated crop insurance payments, drought was the hazard with the highest dollar amount of claims paid for insured crops in Missouri during this fifteen year period.

The impacts of drought have been assessed through the vantage point of agricultural losses. The main reason for this is due to the excellent agricultural insurance data that is available for both recent and past years. As part of the next Plan update process, SEMA will revisit available data sets to determine if additional assessments are possible; as drought does produce impacts beyond agriculture (i.e. – structural).

Figure 3.5.9.3 - Annualized Drought Crop Insurance Claims Paid from 1998-2012



Changes in Development for Jurisdictions in Hazard Prone Areas

Areas that appear to be the most vulnerable to drought are the focus of future drought planning, management, and mitigation activities in the Missouri Drought Plan future updates. Also, as counties experience significant increases in population it will create greater demands on water resources. Of the counties that were determined to be highly vulnerable or moderately highly vulnerable to drought as a result of this analysis, Ralls County is the only one that ranks among Missouri's top counties for population growth.

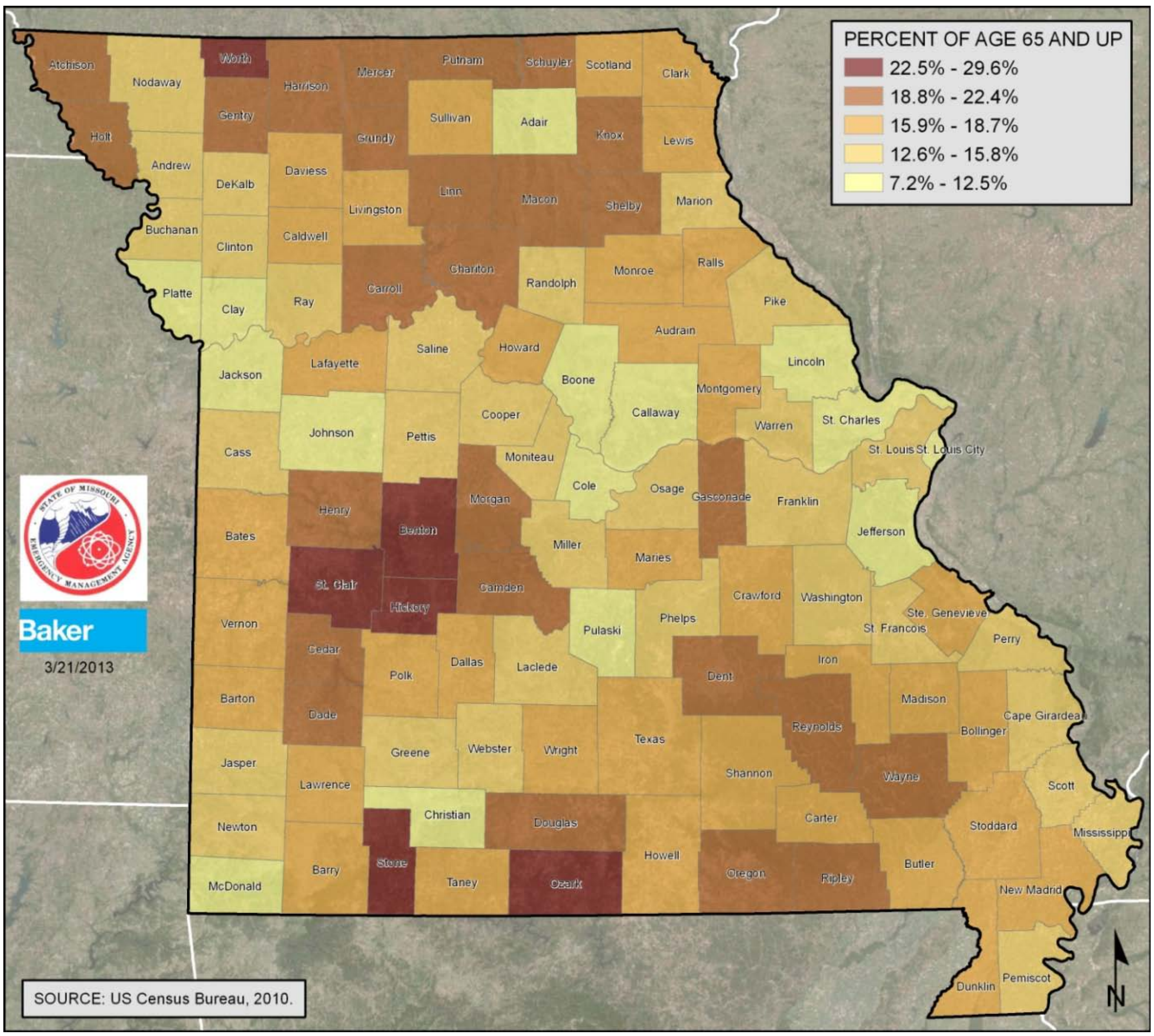
3.5.10 Extreme Temperature

For hazard profile information for heat wave, see Section 3.3.10.

Overview and Analysis of Vulnerability to Extreme Temperature

All Missouri communities are vulnerable to the impacts of extreme temperature. However, those with a higher percentage of elderly may be more at risk due to the heightened vulnerability of this segment of the population. As seen in Figure 3.5.10.1 below, there are 6 Missouri counties that have between 22.5 and 29.6 percent of their population over the age of 65 (US Census Bureau, 2010). According to the 2007-2011 American Community Survey, 13.9% of Missouri's total population is over age 65. Impoverished people living in urban neighborhoods are also more vulnerable to extreme temperatures. According to the 2007-2011 American Community Survey, the percentage of people below the poverty level statewide is about 10.3 percent, however, Jackson County is at 12.5 percent and St. Louis City is at 21 percent (US Census Bureau, 2011).

Figure 3.5.10.1 - Distribution of Elderly Population

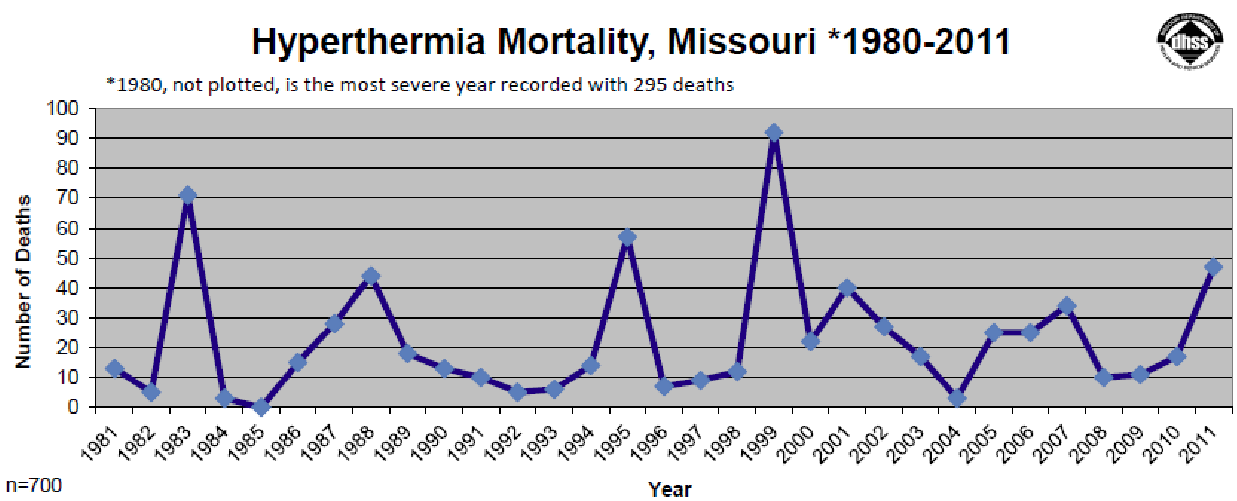


Overview and Analysis of Potential Loss Estimates to Heat Wave

Missouri's highest temperatures generally occur in July and August each summer. Thus, the majority of hot-weather-related deaths also occur during these months.

Missouri operates an on-going statewide surveillance for hot and cold weather-related illnesses and deaths. The program began after a heat wave in 1980 that resulted in 295 heat-related deaths (Missouri DHSS, 2013). Health care providers are required to report cases of hyperthermia to the Missouri Department of Health and Senior Services. In recent history, the year of 1980 stands alone with the highest number hyperthermia deaths with 295 deaths, though it is not included on Figure 3.5.10.2 below.

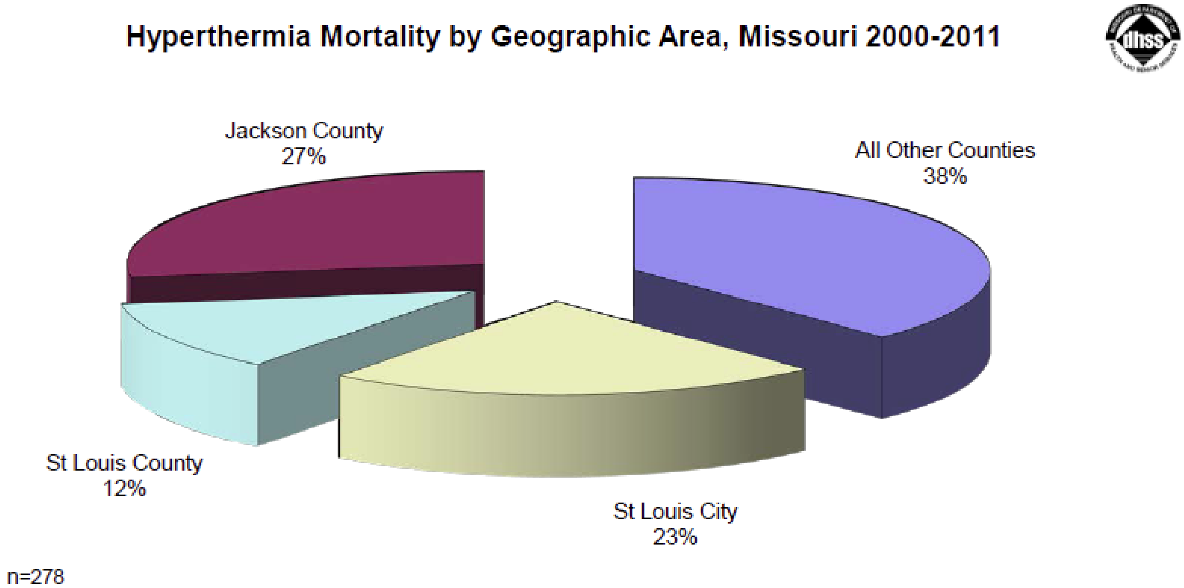
Figure 3.5.10.2 - Hyperthermia Deaths, Missouri, 1980-2008



Source: Missouri Department of Health and Senior Services, http://health.mo.gov/living/healthcondiseases/hyperthermia/pdf/hyper1.pdf, 2011

The Missouri Department of Health and Senior Services gave a preliminary estimate of 47 heat-related deaths from 2011-2012. The 278 deaths from 2000-2011, 128, or 46.0 percent were during the month of July and 98 (35.25 percent) were in August. These fatalities were mainly were recorded in the metropolitan areas of St Louis City and Jackson County as shown in Figure 3.5.10.3 below.

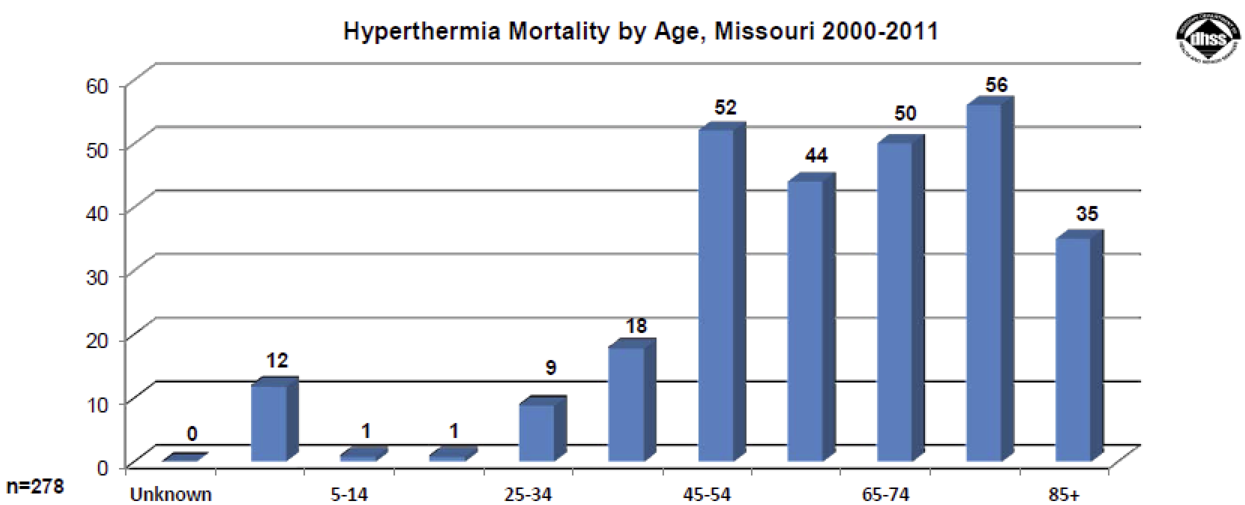
Figure 3.5.10.3 - Hyperthermia Deaths by Geographic Area, Missouri, 2000-2008



Source: Missouri Department of Health and Senior Services, http://health.mo.gov/living/healthcondiseases/hyperthermia/pdf/hyper9.pdf, 2011

Slightly more than half 141 (50.7 percent) of the 278 deaths during 2000-2011 were in the 65 year and older age group. Victims in this population often live alone and have other complicating medical conditions. Also, lack of air conditioning or refusal to use it for fear of higher utility expense contributes to the number of deaths in the senior population. There were 125 (about 45 percent) hyperthermia deaths occurring in the 5 through 64-year-old age group. These deaths often have contributing causes such as physical activity (sports or work), complicating medical conditions, or substance abuse. Circumstances causing hyperthermia deaths in young children often involve a motor vehicle—a child left in or climbing into a parked vehicle during hot weather. From 2000-2011, there were 12 (4.3 percent) deaths of children less than five years of age (see Figure 3.5.10.4 below) (Missouri DHSS, 2011).

Figure 3.5.10.4 - Hyperthermia Deaths by Age, Missouri, 2000-2008



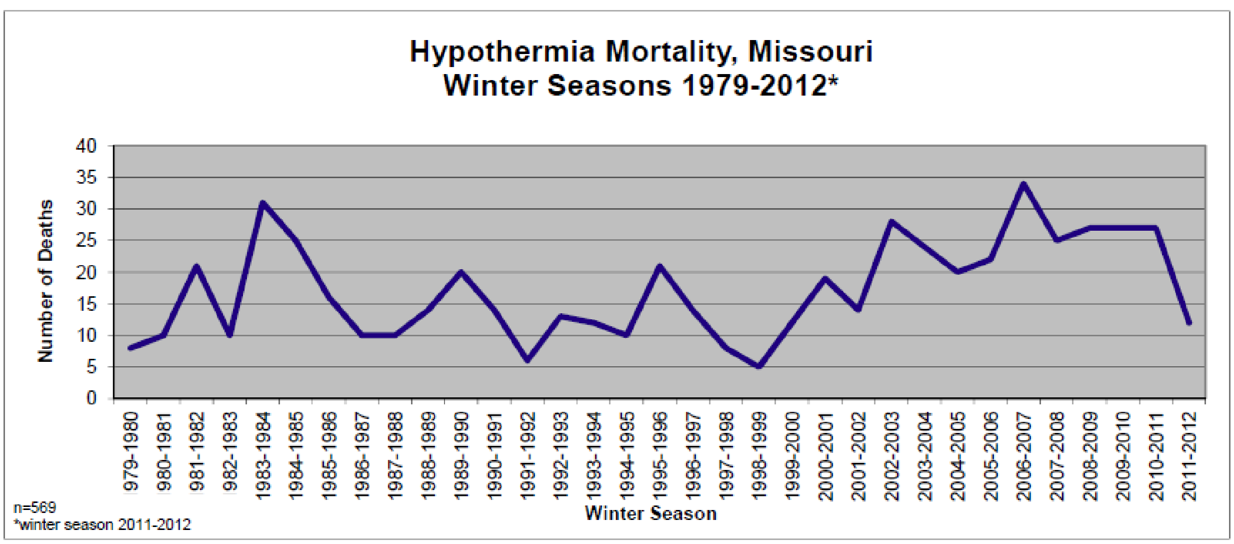
Source: Missouri Department of Health and Senior Services, http://health.mo.gov/living/healthcondiseases/hyperthermia/pdf/hyper4.pdf/, 2011

Overview and Analysis of Potential Loss Estimates to Extreme Cold

The coldest temperatures in Missouri occur each winter in December and January. Thus, the majority of deaths due to hypothermia also occur during these months.

Data from the Missouri Department of Health and Senior Services shows that, in Missouri, 569 people have died from the cold during the winter months between 1979 and 2012 (data collection of hypothermia first began in Missouri in 1979) (see Figure 3.5.10.6) (Missouri DHSS, 2013).

Figure 3.5.10.6 - Hypothermia Deaths, Missouri: Winter Seasons 1979–2012

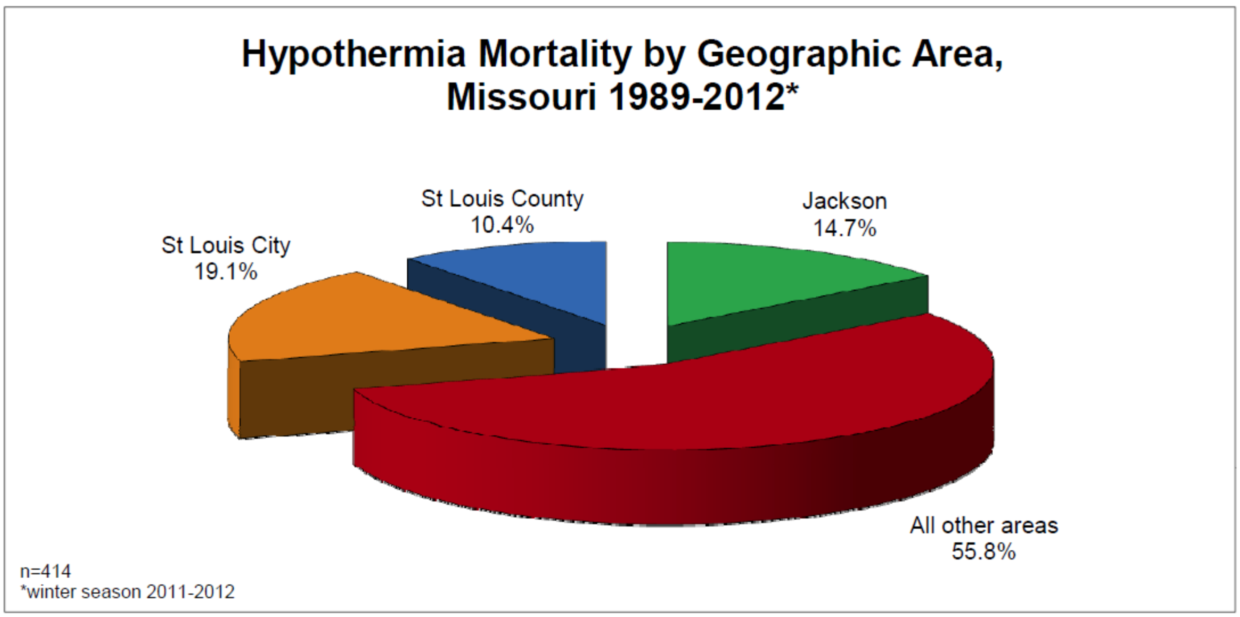


Source: Missouri Department of Health and Senior Service, http://health.mo.gov/living/healthcondiseases/hypothermia/pdf/hypo1.pdf

The elderly are more likely to be victims of cold-related illness resulting in death. Too often, handicapped or elderly individuals fall outside their homes and are unable to reach shelter or help. During the cold weather seasons 1989–2012, 186 (45.0 percent) hypothermia deaths were of people aged 65 years and older. Deaths of individuals between the ages of 25 and 64 often have a contributing cause of substance abuse or a debilitating medical condition. Since 1989, there have been 208 (50.0 percent) hypothermia deaths in this population. Deaths in people age <25 years are rare, accounting for only 20 (4.8 percent) of the total 414 Missouri hypothermia deaths during this time frame. Two of the deaths were children less than 5 years of age. From cold weather winter seasons 1989 through 2012, the largest number of deaths were among males, making up 72.2 percent (299) of the 414 total cold-related deaths.

In Missouri, slightly more deaths have occurred in the more rural areas of the State than in the metropolitan areas. Jackson County had 61 (14.7 percent) deaths, St. Louis County had 43 (10.4 percent), and St. Louis City had 79 (19.1 percent) of the total 414 hypothermia deaths since 1989 (see Figure 3.5.10.7) (Missouri DHSS, 2013).

Figure 3.5.10.7 - Hypothermia Deaths by Geographic Area, Missouri: 1989–2012*



Source: Missouri Department of Health and Senior Services, http://health.mo.gov/living/healthcondiseases/hypothermia/pdf/hypo9.pdf

Changes in Development for Jurisdictions in Hazard Prone Areas

As the population in the above 65 years old category increases, counties will experience greater hyperthermia and hypothermia deaths in Missouri when extreme temperatures occur.

3.5.11 Fires (Urban/Structural and Wild)

For hazard profile information for fires, see Section 3.3.11.

Overview and Analysis of Vulnerability to Fires

Urban/Structural Fire

Statistical analysis of data from the National Fire Incident Reporting System (NFIRS) from 2009 to 2012 was the method utilized to determine overall statewide vulnerability to urban/structural fire across Missouri counties. Currently, 57% of fire departments statewide report incidents to the NFIRS (MDFS, 2013). Although not all departments report to this system, it is the best available data from which to perform the statistical analysis. The incident types considered for urban/structural fire were those in the incident series 100-139. These incident types include all fires in the following categories: 1) fires,-other, 2) structure fire, 3) fire in mobile property used as a fixed structure, and 4) mobile property (vehicle) fire. The fire incident types not considered for urban/structural fire are the considered wildfire incident types in the incident series 140-173 which include: 1) natural vegetation fire, 2) outside rubbish fire, 3) special outside fire, and 4) cultivated vegetation, crop fire.

The five factors considered in the vulnerability analysis were: housing density, likelihood, building exposure, annualized property loss ratio, and a death/injury factor. The death/injury factor was computed by applying a multiplier of two (2) to deaths that occurred in each county and adding it to the total number of injuries that occurred. The death/injury factor was weighted in this manner in an effort to capture any trends in fires that result in deaths or injuries since life-safety is the first priority for mitigation/response efforts.

After compiling historical statistics, and computing to determine the factor values for each county, each factor was divided into 5 ranges with 5 being the highest and 1 being the lowest. Table 3.5.11a provides that ranges that were applied to each factor.

Table 3.5.11a Ranges for Urban/Structure Fire Vulnerability Factor Ratings

Factors Considered	Low (1)	Medium-low (2)	Medium (3)	Medium-high-4	High (5)
Housing Density (# per sq. mile)	<50	50 to 99	100 to 199	200 to 499	>500
Urban Fire Likelihood (# of events/ yrs. of data)	0 to 49	50 to 99	100 to 299	300 to 499	500+
Building Exposure ($)	<$0.5B	$0.5B to $0.9B	$1B to $1.9B	$2B to $5.9B	>6B
Annualized Property Loss Ratio Rating(annual property loss/ exposure)	0-.000099	.0001 to .000299	.0003 to .000599	.0006 to .000999	.001 +
Death/Injury Rating (2X # of deaths + # of injuries)	0 to 4	5 to 9	10 to 19	20 to 49	50+
Death/Injury/Number of events Rating (Death Injury Rating factor/ # of events)	0 to 0.1	0.1 to 0.2	0.2 to 0.3	0.3 to 0.4	0.4+
Overall Vulnerability Rating (Average of all ratings)	1 to 1.67	1.67 to 2.35	2.36 to 3.03	3.04 to 3.71	3.72 to 4.4

Table 3.5.11b provides the detailed statistical data that was used for the vulnerability analysis for urban/structural fire for each county from 2009-2012. The shaded columns are the factor ratings established by applying the above ranges. According to this data, the average annual number of fires in Missouri was 23,051 causing estimated total annual average damages in the amount of $3,709,720,410. The map that follows, Figure 3.5.11.1, provides the statewide results for the likelihood factor followed by the map that provides the overall vulnerability rating calculated by assigning an equal weight to each of the five contributing factors.

Statistical Methodology Limitations: It should be noted that there are limiting factors inherent to the NFIRS source data. According to the Missouri Department of Fire Safety, just 57% of Missouri Fire Departments reported to the system (MDFS, 2013). Another possible application for the death/injury rating is to develop a death/injury rating per the number of fires. Other factors to consider if data is available are the age of structures, building materials used, surrounding terrain and vegetation, occupancy status and status of regulatory oversight. These types of details are not consistently available on a statewide level. However, they may be more readily available at the local level

Table 3.5.11b Statistical Data and Factor Ratings for Urban/Structure Fire Vulnerability (2004-2008) (US Census, 2010)

County	Housing Units /sq. mi.	Housing Density Rating	Annual # Average	Likelihood Rating	Total Building Exposure ($)	Building Exposure Rating	Average Annual Property Loss ($)	Annual Property Loss Ratio	Property Loss Ratio Rating	Total Deaths/Injuries		Death /Injury Factor	Death/Injury Factor Rating	Death /Injury/# of Fires Factor	Death/Injury/# of Fires Factor Rating	Average of factors	Overall Vulnerability Rating
Adair	19.9	1	2	1	2,464,315,000	4	91,750	0.000037	1	0	0	0	1	0.00	1	1.6	1
Andrew	16.9	1	18	1	1,599,380,000	3	43,438	0.000027	1	0	2	2	1	0.11	2	1.6	1
Atchison	5.5	1	24	1	650,419,000	2	209,750	0.000322	3	0	0	0	1	0.00	1	1.6	1
Audrain	15.7	1	40	1	2,442,664,000	4	127,354	0.000052	1	0	0	0	1	0.00	1	1.6	1
Barry	22.5	1	235	3	3,161,148,000	4	2,348,775	0.000743	4	33	7	73	5	0.31	4	3.6	4
Barton	9.5	1	68	2	1,301,748,000	3	1,250	0.000001	1	3	0	6	2	0.09	1	1.6	1
Bates	9.4	1	65	2	1,598,983,000	3	617,283	0.000386	3	2	19	23	4	0.35	4	3	3
Benton	20.1	1	92	2	2,240,532,000	4	600,846	0.000268	2	1	15	17	3	0.19	2	2.4	3
Bollinger	9.5	1	32	1	952,545,000	2	26,350	0.000028	1	0	0	0	1	0.00	1	1.2	1
Boone	101.5	3	250	3	17,363,239,000	5	1,703,748	0.000098	1	2	13	17	3	0.07	1	2.6	3
Buchanan	94.2	2	453	4	9,701,152,000	5	4,742,961	0.000489	3	9	72	90	5	0.20	3	3.6	4
Butler	28.4	1	375	1	3,682,173,000	4	1,013	0.000000	1	8	30	46	4	0.12	2	2.4	3
Caldwell	10.8	1	33	1	942,135,000	2	190,355	0.000202	2	10	3	23	4	0.69	5	2.8	3
Callaway	22.2	1	161	3	4,134,300,000	4	933,628	0.000226	2	9	7	25	4	0.16	2	2.6	3
Camden	62.8	2	247	3	7,136,339,000	5	823,724	0.000115	2	28	67	123	5	0.50	5	3.8	5
Cape Girardeau	56.4	2	131	3	7,957,433,000	5	1,018,812	0.000128	2	3	8	14	3	0.11	2	2.8	3
Carroll	6.7	1	91	2	1,066,261,000	3	246,388	0.000231	2	14	164	192	5	2.11	5	3.2	4
Carter	6.4	1	3	1	530,088,000	2	6,250	0.000012	1	0	0	0	1	0.00	1	1.2	1
Cass	57.5	2	314	4	10,245,424,000	5	2,922,337	0.000285	2	0	40	40	4	0.13	2	3	3
Cedar	15.2	1	101	3	1,377,577,000	3	280,773	0.000204	2	2	13	17	3	0.17	2	2.2	2

County	Housing Units /sq. mi.	Housing Density Rating	Annual # Average	Likelihood Rating	Total Building Exposure ($)	Building Exposure Rating	Average Annual Property Loss ($)	Annual Property Loss Ratio	Property Loss Ratio Rating	Total Deaths/Injuries		Death /Injury Factor	Death/Injury Factor Rating	Death /Injury/# of Fires Factor	Death/Injury/# of Fires Factor Rating	Average of factors	Overall Vulnerability Rating
Chariton	5.6	1	39	1	821,795,000	2	77,711	0.000095	1	0	0	0	1	0.00	1	1.2	1
Christian	56.1	2	318	4	6,354,341,000	5	1,154,653	0.000182	2	4	16	24	4	0.08	1	2.8	3
Clark	6.9	1	26	1	614,995,000	2	199,013	0.000324	3	1	3	5	2	0.19	2	2	2
Clay	236.5	4	301	4	25,240,363,000	5	2,821,315	0.000112	2	1	54	56	5	0.19	2	3.6	4
Clinton	21.2	1	133	3	2,143,758,000	4	762,583	0.000356	3	8	4	20	4	0.15	2	2.8	3
Cole	82.1	2	64	2	9,105,948,000	5	338,115	0.000037	1	1	1	3	1	0.05	1	2	2
Cooper	13.2	1	81	2	1,698,351,000	3	1,139,950	0.000671	4	8	1	17	3	0.21	3	2.8	3
Crawford	16.1	1	195	3	2,166,540,000	4	500,454,576	0.230993	5	13	98	124	5	0.64	5	4	5
Dade	8.1	1	46	1	712,879,000	2	56,600	0.000079	1	3	1	7	2	0.15	2	1.6	1
Dallas	14.2	1	35	1	1,297,333,000	3	385,418	0.000297	2	4	2	10	3	0.29	3	2.4	3
Daviess	7.5	1	69	2	865,596,000	2	498,838	0.000576	3	1	4	6	2	0.09	1	1.8	2
DeKalb	10.3	1	61	2	891,756,000	2	432,096	0.000485	3	1	1	3	1	0.05	1	1.6	1
Dent	9.7	1	66	2	1,382,572,000	3	883,313	0.000639	4	1	2	4	1	0.06	1	2	2
Douglas	8	1	39	1	1,029,008,000	3	481,425	0.000468	3	2	1	5	2	0.13	2	2.2	2
Dunklin	26.7	1	108	3	2,492,777,000	4	903,143	0.000362	3	2	6	10	3	0.09	1	2.4	3
Franklin	47.1	1	497	4	10,276,147,000	5	2,720,556	0.000265	2	3	28	34	4	0.07	1	2.6	3
Gasconade	15.9	1	65	2	1,699,937,000	3	530,075	0.000312	3	1	3	5	2	0.08	1	2	2
Gentry	6.5	1	1	1	646,605,000	2	0	0.000000	1	0	0	0	1	0.00	1	1.2	1
Greene	185.8	3	1308	5	27,949,700,000	5	7,497,115	0.000268	2	22	123	167	5	0.13	2	3.4	4
Grundy	11.5	1	98	2	1,023,068,000	3	906,142	0.000886	4	5	6	16	3	0.16	2	2.6	3
Harrison	6.1	1	41	1	975,597,000	2	398,913	0.000409	3	3	2	8	2	0.19	2	2	2

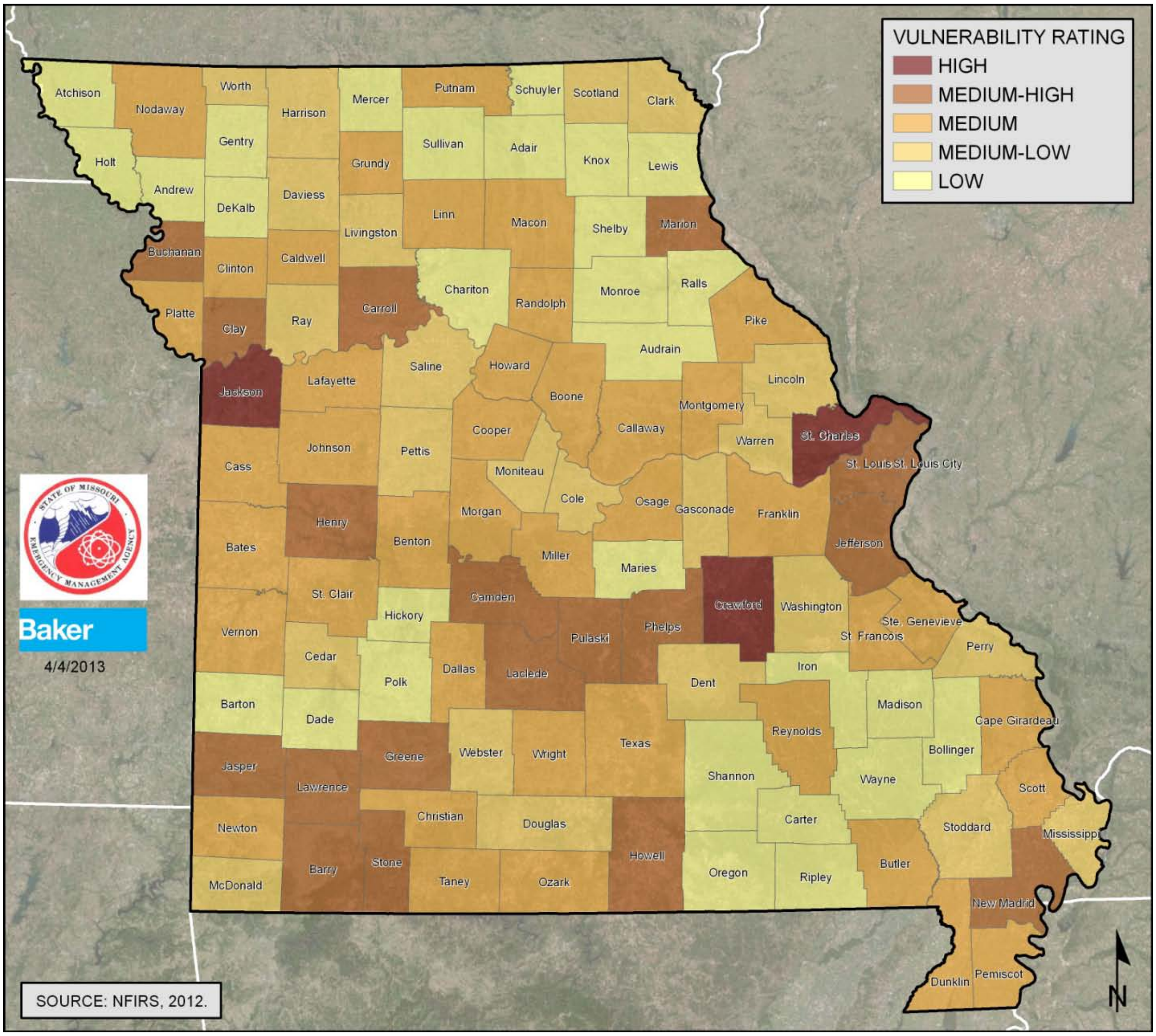
County	Housing Units /sq. mi.	Housing Density Rating	Annual # Average	Likelihood Rating	Total Building Exposure ($)	Building Exposure Rating	Average Annual Property Loss ($)	Annual Property Loss Ratio	Property Loss Ratio Rating	Total Deaths/Injuries		Death /Injury Factor	Death/Injury Factor Rating	Death /Injury/# of Fires Factor	Death/Injury/# of Fires Factor Rating	Average of factors	Overall Vulnerability Rating
Henry	15.6	1	149	3	2,383,450,000	4	1,403,733	0.000589	3	13	23	49	4	0.33	4	3.2	4
Hickory	17.1	1	24	1	898,778,000	2	103,625	0.000115	2	2	0	4	1	0.16	2	1.6	1
Holt	6.1	1	21	1	591,854,000	2	220,081	0.000372	2	0	0	0	1	0.00	1	1.4	1
Howard	9.9	1	89	2	1,010,144,000	3	4,681	0.000005	1	12	500	524	5	5.92	5	3	3
Howell	19.4	1	255	3	3,408,131,000	4	1,589,394	0.000466	3	24	176	224	5	0.88	5	3.6	4
Iron	9.7	1	61	2	960,981,000	2	165,975	0.000173	1	1	0	2	1	0.03	1	1.2	1
Jackson	516.6	5	3195	5	83,385,516,000	5	3,093,587,180	0.037100	5	24	188	236	5	0.07	1	4.2	5
Jasper	79.4	2	629	5	10,870,600,000	5	3,556,000	0.000327	3	8	50	66	5	0.11	2	3.4	4
Jefferson	133.5	3	632	5	20,529,358,000	5	2,553,764	0.000124	2	10	79	99	5	0.16	2	3.4	4
Johnson	26	1	191	3	5,052,926,000	4	818,586	0.000162	2	2	32	36	4	0.19	2	2.6	3
Knox	4.5	1	7	1	398,969,000	1	61,250	0.000154	2	1	0	2	1	0.28	3	1.6	1
Laclede	20.6	1	113	3	2,898,589,000	4	223,308	0.000077	1	11	53	75	5	0.67	5	3.2	4
Lafayette	23.4	1	162	3	3,519,546,000	4	538,540	0.000153	2	5	6	16	3	0.10	2	2.4	3
Lawrence	27.2	1	137	3	3,324,370,000	4	1,223,428	0.000368	3	8	25	41	4	0.30	4	3.2	4
Lewis	9	1	45	1	899,056,000	2	250,225	0.000278	2	0	0	0	1	0.00	1	1.4	1
Lincoln	33.6	1	248	3	4,340,031,000	4	1,163,485	0.000268	2	3	8	14	3	0.06	1	2.2	2
Linn	10.4	1	49	1	1,313,208,000	3	226,838	0.000173	2	4	3	11	3	0.23	3	2.4	3
Livingston	12.6	1	39	1	1,385,494,000	3	223,220	0.000161	2	0	8	8	2	0.21	3	2.2	2
Macon	9.6	1	33	1	1,498,071,000	3	353,298	0.000236	2	2	16	20	4	0.60	5	3	3
Madison	12.1	1	61	2	1,460,266,000	3	500	0.000000	1	0	3	3	1	0.05	1	1.4	1
Maries	8.8	1	28	1	1,091,078,000	3	94,725	0.000087	1	1	0	2	1	0.07	1	1.4	1
Marion	29.4	1	176	3	851,638,000	2	1,086,442	0.001276	5	8	40	56	5	0.32	4	3.4	4

County	Housing Units /sq. mi.	Housing Density Rating	Annual # Average	Likelihood Rating	Total Building Exposure ($)	Building Exposure Rating	Average Annual Property Loss ($)	Annual Property Loss Ratio	Property Loss Ratio Rating	Total Deaths/Injuries		Death /Injury Factor	Death/Injury Factor Rating	Death /Injury/# of Fires Factor	Death/Injury/# of Fires Factor Rating	Average of factors	Overall Vulnerability Rating
McDonald	18.4	1	74	2	2,789,835,000	4	76,838	0.000028	1	1	3	5	2	0.07	1	1.8	2
Mercer	4.7	1	31	1	367,552,000	1	11,025	0.000030	1	2	4	8	2	0.26	3	1.6	1
Miller	21.5	1	80	2	2,194,585,000	4	2,120,003	0.000966	4	2	3	7	2	0.09	1	2.4	3
Mississippi	13.9	1	106	3	1,066,614,000	3	1,747,609	0.001638	5	1	2	4	1	0.04	1	2.2	2
Moniteau	14.9	1	88	2	1,315,933,000	3	1,201,209	0.000913	4	0	0	0	1	0.00	1	2	2
Monroe	7.4	1	36	1	900,582,000	2	76,925	0.000085	1	0	0	0	1	0.00	1	1.2	1
Montgomery	11.4	1	61	2	1,254,588,000	3	602,800	0.000480	3	4	8	16	3	0.26	3	2.6	3
Morgan	26	1	113	3	2,518,783,000	4	978,530	0.000388	3	1	14	16	3	0.14	2	2.6	3
New Madrid	12.6	1	140	3	1,569,929,000	3	1,249,658	0.000796	4	14	14	42	4	0.30	4	3.2	4
Newton	38.9	1	277	3	5,027,857,000	4	1,678,486	0.000334	3	6	16	28	4	0.10	2	2.8	3
Nodaway	10.9	1	51	2	2,097,395,000	4	704,963	0.000336	3	1	7	9	2	0.18	2	2.4	3
Oregon	6.9	1	66	2	842,686,000	2	128,950	0.000153	2	2	2	6	2	0.09	1	1.6	1
Osage	10.8	1	41	1	1,427,835,000	3	194,863	0.000136	2	7	25	39	4	0.95	5	3	3
Ozark	7.6	1	83	2	784,866,000	2	892,031	0.001137	5	8	6	22	4	0.26	3	3	3
Pemiscot	16.6	1	82	2	1,433,654,000	3	1,418,838	0.000990	4	5	2	12	3	0.15	2	2.6	3
Perry	18.1	1	47	1	2,124,249,000	4	738,138	0.000347	3	1	0	2	1	0.04	1	2	2
Pettis	26.8	1	190	3	4,311,203,000	4	313,200	0.000073	1	6	0	12	3	0.06	1	2	2
Phelps	29.1	1	201	3	4,283,040,000	4	1,020,777	0.000238	2	26	135	187	5	0.93	5	3.4	4
Pike	11.8	1	25	1	1,732,955,000	3	22,476	0.000013	1	5	36	46	4	1.86	5	2.8	3
Platte	93.4	2	158	3	10,180,565,000	5	666,891	0.000066	1	2	39	43	4	0.27	3	3	3

County	Housing Units /sq. mi.	Housing Density Rating	Annual # Average	Likelihood Rating	Total Building Exposure ($)	Building Exposure Rating	Average Annual Property Loss ($)	Annual Property Loss Ratio	Property Loss Ratio Rating	Total Deaths/Injuries		Death /Injury Factor	Death/Injury Factor Rating	Death /Injury/# of Fires Factor	Death/Injury/# of Fires Factor Rating	Average of factors	Overall Vulnerability Rating
Polk	20.9	1	69	2	2,506,838,000	4	2,075	0.000001	1	1	1	3	1	0.04	1	1.6	1
Pulaski	32.7	1	185	3	3,755,326,000	4	426,824	0.000114	2	15	115	145	5	0.79	5	3.4	4
Putnam	5.8	1	13	1	493,213,000	1	209,819	0.000425	3	3	9	15	3	1.18	5	2.6	3
Ralls	11	1	25	1	1,036,049,000	3	3,375	0.000003	1	0	0	0	1	0.00	1	1.4	1
Randolph	22.2	1	139	3	2,337,954,000	4	1,241,845	0.000531	3	6	8	20	4	0.14	2	2.8	3
Ray	17.6	1	149	3	2,357,316,000	4	458,450	0.000194	2	3	3	9	2	0.06	1	2	2
Reynolds	5	1	44	1	717,542,000	2	112,275	0.000156	2	4	9	17	3	0.39	4	2.4	3
Ripley	10.5	1	24	1	1,050,116,000	3	144,450	0.000138	2	0	0	0	1	0.00	1	1.6	1
Saline	13.4	1	82	2	2,326,438,000	4	686,711	0.000295	2	0	2	2	1	0.02	1	1.8	2
Schuyler	6.8	1	0	1	369,094,000	1	0	0.000000	1	0	0	0	1	0.00	1	1	1
Scotland	5.4	1	30	1	475,226,000	1	761,613	0.001603	5	1	1	3	1	0.10	2	2	2
Scott	40.5	1	222	3	3,636,518,000	4	1,415,352	0.000389	3	5	15	25	4	0.11	2	2.8	3
Shannon	4.2	1	64	2	725,557,000	2	427,514	0.000589	3	0	0	0	1	0.00	1	1.6	1
Shelby	6.4	1	7	1	677,622,000	2	1,163	0.000002	1	0	0	0	1	0.00	1	1.2	1
St. Charles	251.7	4	676	5	39,157,150,000	5	8,001,810	0.000204	2	8	150	166	5	0.25	3	3.8	5
St. Clair	8.4	1	72	2	949,294,000	2	395,611	0.000417	3	3	18	24	4	0.33	4	2.8	3
St. Francois	63	2	297	3	6,073,289,000	5	1,542,971	0.000254	2	8	13	29	4	0.10	2	3	3
St. Louis	863	5	1,637	5	41,414,257,000	5	11,010,704	0.000266	2	10	175	369	5	0.08	1	3.6	4
St. Louis City*	2847.9	5	11,647	5	127,497,738,000	5	6,481,025	0.000051	1	13	148	174	5	0.06	1	3.4	4
Ste. Genevieve	17.3	1	69	2	1,967,405,000	3	484,900	0.000246	2	6	10	22	4	0.32	4	2.8	3

County	Housing Units /sq. mi.	Housing Density Rating	Annual # Average	Likelihood Rating	Total Building Exposure ($)	Building Exposure Rating	Average Annual Property Loss ($)	Annual Property Loss Ratio	Property Loss Ratio Rating	Total Deaths/Injuries		Death /Injury Factor	Death/Injury Factor Rating	Death /Injury/# of Fires Factor	Death/Injury/# of Fires Factor Rating	Average of factors	Overall Vulnerability Rating
Stoddard	16.5	1	139	3	2,589,294,000	4	669,575	0.000259	2	5	2	12	3	0.09	1	2.2	2
Stone	43.9	1	253	3	3,376,042,000	4	187,032	0.000055	1	4	140	148	5	0.59	5	3.2	4
Sullivan	5.2	1	3	1	566,143,000	2	31,500	0.000056	1	0	0	0	1	0.00	1	1.2	1
Taney	46.3	1	332	4	4,708,947,000	4	3,004,301	0.000638	4	3	12	18	3	0.05	1	2.6	3
Texas	9.9	1	179	3	2,059,876,000	4	1,188,786	0.000577	3	6	13	25	4	0.14	2	2.8	3
Vernon	11.5	1	77	2	2,352,179,000	4	664,808	0.000283	2	2	8	12	3	0.16	2	2.4	3
Warren	34.3	1	152	3	3,105,665,000	4	937,188	0.000302	3	2	5	9	2	0.06	1	2.2	2
Washington	14.5	1	301	4	1,678,841,000	3	388,550	0.000231	2	5	17	27	4	0.09	1	2.2	2
Wayne	10.7	1	17	1	1,181,550,000	3	0	0.000000	1	0	0	0	1	0.00	1	1.4	1
Webster	24.3	1	132	3	2,628,891,000	4	306,850	0.000117	2	0	3	3	1	0.02	1	1.8	2
Worth	4.8	1	15	1	248,027,000	1	273675	0.001103	5	0	0	0	1	0.00	1	1.8	2
Wright	12.8	1	130	3	1,489,037,000	3	3,388,852	0.002276	5	4	6	14	3	0.11	2	2.8	3
Totals		-	**23,051**	-	**645,742,115,000**	-	**3,709,720,410**	-	-	**558**	**3,225**	-	-			-	-

Figure 3.5.11.1 - Vulnerability to Urban/Structure Fire



According to this analysis, the following counties have a high vulnerability to urban/structural fires: Camden, Crawford, Jackson, and St. Charles.

Wildfire

With over 14 million acres, Missouri ranks seventh in the northeast region of the U.S. in forest land area (CCM, 2013). Although the National Fire Incident Reporting System does capture data on wildfires, it was determined that the Department of Conservation historical wildfire data was the best resource. Both sets of data were reviewed for the 2004-2008 time period. The Department of Conservation data had more individual events recorded per county. Therefore, this data appeared to be more comprehensive. Some fire departments report to both data sets. So, adding the two sets of data together would have double-counted fires. From the Department of Conservation wildfire data from 1993 to 2012, it was determined that the average annual number of wildfires in Missouri was 3,084 burning an average annual 53,460 acres (MDC, 2013).

From the data obtained from the Department of Conservation, two factors were considered in the overview vulnerability analysis: likelihood and annualized acres burned.

After compiling historical statistics, and computing to determine the factor values for each county, each factor was divided into 5 ranges with 5 being the highest and 1 being the lowest. Table 3.5.11b-1 provides that ranges that were applied to each factor.

Table 3.5.11b-1 Ranges for Wildfire Vulnerability Factor Ratings

Factors Considered	Low (1)	Medium-low (2)	Medium (3)	Medium-high-4	High (5)
	Level 1 Range	Level 2 Range	Level 3 Range	Level 4 Range	Level 5 Range
Likelihood Rating	<29.56	29.56 to 59.11	59.12 to 88.67	88.68 to 118.23	>118.23
Annualized Acres Burned Rating	<100	100 to199	200 to 499	500 to 999	>999
Vulnerability (Average of values above)	0.0 to 1.0	1.0 to 2.0	2.0 to 3.0	3.0 to 4.0	4.0 to 5.0

Table 3.5.11c, below, provides the detailed statistical data that was used for the vulnerability analysis for wildfire for each county. Deaths and injuries were not included in the analysis as the data was not available in the DOC data that was selected for analysis. The shaded columns are the factor ratings established by applying the above ranges. The map in Figure 3.5.11.2 that follows provides the statewide results for the likelihood factor followed by the map that provides the overall vulnerability rating calculated by assigning an equal weight to the 2 contributing factors.

Table 3.5.11c Statistical Data and Factor Ratings for Wildfire Vulnerability

County	Wildfires 2004-2012	Average Annual # of Wildfires	Likelihood Rating 1-5	Acres Burned	Average Annual Acres Burned	Average Acres Burned Rating	Total Buildings Damaged	Overall Vulnerability
Adair	125	13.9	1	1401.18	156	2	3	2
Andrew	315	35	2	2470.91	275	3	11	3
Atchison	169	18.8	1	1591.35	177	2	0	2
Audrain	113	12.6	1	524.13	58	1	1	1
Barry	356	39.6	2	3977.43	442	3	7	3
Barton	73	8.1	1	1479	164	2	2	2
Bates	187	20.8	1	2832.57	315	3	3	3
Benton	736	81.8	3	14993.62	1666	5	31	4
Bollinger	265	29.4	1	1844	205	3	7	2
Boone	2	0.2	1	50.1	6	1	0	1
Buchanan	402	44.7	2	2185.76	243	3	5	3
Butler	899	99.9	4	3767.78	419	3	15	4
Caldwell	111	12.3	1	3636.23	404	3	2	2

Callaway	353	39.2	2	2951.74	328	3	3	3
Camden	1786	198.4	5	47214.41	5246	5	38	5
Cape Girardeau	286	31.8	2	2037.32	226	3	2	3
Carroll	261	29	1	7409.75	823	4	1	3
Carter	95	10.6	1	5983.12	665	4	14	3
Cass	266	29.6	1	1225.55	136	2	0	2
Cedar	305	33.9	2	3402.7	378	3	4	3
Chariton	151	16.8	1	1835.43	204	3	4	2
Christian	169	18.8	1	1547.25	172	2	5	2
Clark	105	11.7	1	734.48	82	1	0	1
Clay	108	12	1	261.32	29	1	0	1
Clinton	404	44.9	2	3817.58	424	3	2	3
Cole	114	12.7	1	638	71	1	2	1
Cooper	266	29.6	2	1658.66	184	2	4	2
Crawford	824	91.6	4	7543.71	838	4	18	4
Dade	376	41.8	2	3959.55	440	3	19	3
Dallas	438	48.7	2	30848.34	3428	5	11	4
Daviess	218	24.2	1	3094.14	344	3	3	2
Dekalb	312	34.7	2	7215.11	802	4	3	3
Dent	260	28.9	1	5077	564	4	5	3
Douglas	269	29.9	1	8618.55	958	4	9	3
Dunklin	5	0.6	1	1.6	0	1	0	1
Franklin	577	64.1	3	1778.8	198	2	10	3
Gasconade	77	8.6	1	846	94	1	3	1
Gentry	197	21.9	1	5427.11	603	4	9	3
Greene	560	62.2	2	2525.21	281	3	23	3
Grundy	78	8.7	1	1208.95	134	2	1	2
Harrison	223	24.8	1	8176.41	908	4	8	3
Henry	636	70.7	3	15506.06	1723	5	23	4
Hickory	137	15.2	1	2786.51	310	3	4	2
Holt	133	14.8	1	813.79	90	1	6	1
Howard	87	9.7	1	1542.25	171	2	0	2
Howell	479	53.2	2	8217.45	913	4	265	3
Iron	127	14.1	1	6299.7	700	4	0	3
Jackson	189	21	1	288.6	32	1	2	1
Jasper	297	33	2	2298.75	255	3	3	3

Jefferson	736	81.8	3	2383.58	265	3	20	3
Johnson	418	46.4	2	1878.2	209	3	4	3
Knox	13	1.4	1	197.5	22	1	0	1
Laclede	410	45.6	2	19800.75	2200	5	7	4
Lafayette	183	20.3	1	921.15	102	2	4	3
Lawrence	430	47.8	2	2326.67	259	3	9	3
Lewis	104	11.6	1	1003.7	112	2	400	2
Lincoln	205	22.8	1	1510.9	168	2	9	2
Linn	99	11	1	2614.2	290	3	0	2
Livingston	81	9	1	2207.55	245	3	1	2
Macon	120	13.3	1	2133	237	3	1	2
Madison	124	13.8	1	867.03	96	1	2	1
Maries	110	12.2	1	3032.7	337	3	2	2
Marion	90	10	1	944.45	105	2	0	2
McDonald	163	18.1	1	2152	239	3	5	2
Mercer	15	1.7	1	115.85	13	1	0	1
Miller	416	46.2	2	3245.52	361	3	8	3
Mississippi	108	12	1	572	64	1	1	1
Moniteau	235	26.1	1	1879.76	209	3	3	2
Monroe	130	14.4	1	2234	248	3	1	2
Montgomery	140	15.6	1	626.84	70	1	0	1
Morgan	570	63.3	3	7255.22	806	4	17	4
New Madrid	93	10.3	1	161	18	1	3	1
Newton	1208	134.2	5	4511.29	501	4	53	5
Nodaway	373	41.4	2	5152.73	573	4	12	3
Oregon	425	47.2	2	4819.15	535	4	20	3
Osage	137	15.2	1	982.5	109	2	3	2
Ozark	327	36.3	2	9583.95	1065	5	6	4
Pemiscot	26	2.9	1	70.35	8	1	1	1
Perry	34	3.8	1	490.85	55	1	0	1
Pettis	121	13.4	1	1540.25	171	2	0	2
Phelps	312	34.7	2	3268.9	363	3	6	3
Pike	110	12.2	1	1399.7	156	2	1	2
Platte	52	5.8	1	137.68	15	1	1	1
Polk	366	40.7	2	3332.72	370	3	14	3
Pulaski	266	29.6	2	2597.3	289	3	1	3

Putnam	62	6.9	1	895.48	99	1	0	1
Ralls	51	5.7	1	845	94	1	1	1
Randolph	270	30	2	2524.95	281	3	3	3
Ray	241	26.8	1	5135.67	571	4	3004	3
Reynolds	372	41.3	2	18070.7	2008	5	7	4
Ripley	284	31.6	2	2858	318	3	14	3
Saline	45	5	1	1381.35	153	2	0	2
Schuyler	48	5.3	1	970.25	108	2	1	2
Scotland	98	10.9	1	1672.75	186	2	2	2
Scott	281	31.2	2	1703.67	189	2	13	2
Shannon	351	39	2	9273.02	1030	5	12	4
Shelby	54	6	1	808.2	90	1	2	1
St. Charles	111	12.3	1	690.6	77	1	2	1
St. Clair	430	47.8	2	15593.94	1733	5	13	4
St. Francois	911	101.2	4	7500.88	833	4	12	4
St. Genevieve	216	24	1	1069.14	119	2	3	2
St. Louis	66	7.3	1	140.91	16	1	0	1
St. Louis City*	9	1	1	1.95	0	1	2	1
Stoddard	368	40.9	2	2172.38	241	3	11	3
Stone	389	43.2	2	3245.63	361	3	5	3
Sullivan	44	4.9	1	808.75	90	1	1	1
Taney	554	61.6	3	6218.4	691	4	21	3
Texas	572	63.6	3	6081.81	676	4	19	4
Vernon	130	14.4	1	4308.41	479	3	5	2
Warren	49	5.4	1	178.91	20	1	1	1
Washington	1183	131.4	5	20408.31	2268	5	44	5
Wayne	186	20.7	1	5525.8	614	4	5	3
Webster	325	36.1	2	3262.14	362	3	20	3
Worth	120	13.3	1	6011.77	668	4	1	3
Wright	497	55.2	2	3963	440	3	33	3
Totals	**31,988**	**3554.2**	-	**476,818**	**52,980**	-	**4,463**	-

County	Wildfires 2004-2012	Average Annual # of Wildfires	Likelihood Rating 1-5	Acres Burned	Average Annual Acres Burned	Average Acres Burned Rating	Total Buildings Damaged	Overall Vulnerability
Adair	125	13.9	1	1401.18	156	2	3	2
Andrew	315	35.0	1	2470.91	275	3	11	3
Atchison	169	18.8	1	1591.35	177	2	0	2
Audrain	113	12.6	1	524.13	58	1	1	1
Barry	356	39.6	2	3977.43	442	3	7	3
Barton	73	8.1	1	1479.00	164	2	2	2
Bates	187	20.8	1	2832.57	315	3	3	3
Benton	736	81.8	3	14993.62	1666	5	31	5
Bollinger	265	29.4	1	1844.00	205	3	7	3
Boone	2	0.2	1	50.10	6	1	0	1
Buchanan	402	44.7	2	2185.76	243	3	5	3
Butler	899	99.9	4	3767.78	419	3	15	4
Caldwell	111	12.3	1	3636.23	404	3	2	3
Callaway	353	39.2	1	2951.74	328	3	3	3
Camden	1786	198.4	5	47214.41	5246	5	38	5
Cape Girardeau	286	31.8	1	2037.32	226	3	2	3
Carroll	261	29.0	1	7409.75	823	4	1	3
Carter	95	10.6	1	5983.12	665	4	14	3
Cass	266	29.6	1	1225.55	136	2	0	2
Cedar	305	33.9	1	3402.70	378	3	4	3
Chariton	151	16.8	1	1835.43	204	3	4	3
Christian	169	18.8	1	1547.25	172	2	5	2
Clark	105	11.7	1	734.48	82	1	0	1
Clay	108	12.0	1	261.32	29	1	0	1
Clinton	404	44.9	1	3817.58	424	3	2	3
Cole	114	12.7	1	638.00	71	1	2	1
Cooper	266	29.6	1	1658.66	184	2	4	2
Crawford	824	91.6	3	7543.71	838	4	18	4
Dade	376	41.8	2	3959.55	440	3	19	3
Dallas	438	48.7	2	30848.34	3428	5	11	4
Daviess	218	24.2	1	3094.14	344	3	3	3
Dekalb	312	34.7	2	7215.11	802	4	3	4
Dent	260	28.9	1	5077.00	564	4	5	3
Douglas	269	29.9	1	8618.55	958	4	9	3
Dunklin	5	0.6	1	1.60	0	1	0	1

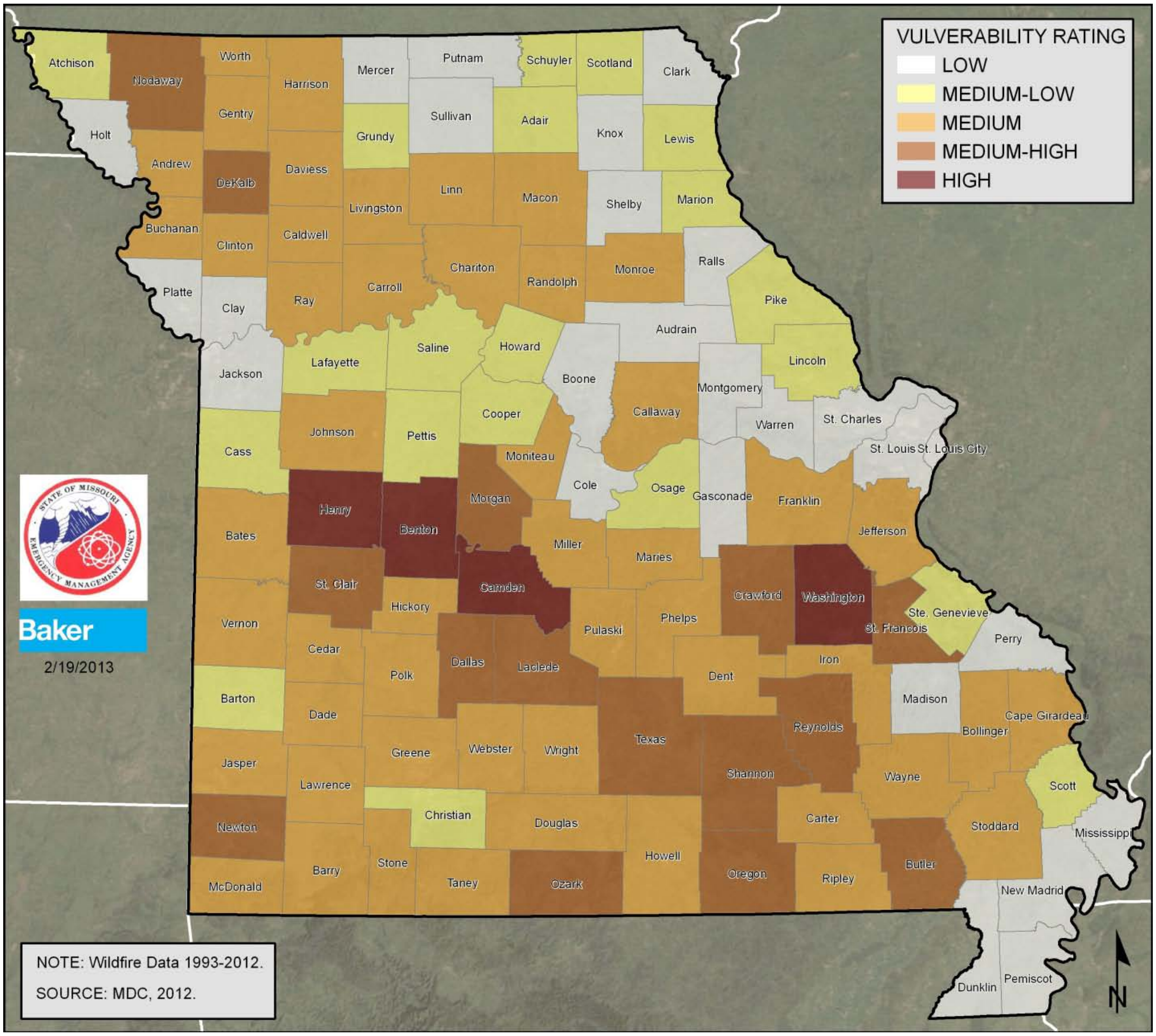
County	Wildfires 2004-2012	Average Annual # of Wildfires	Likelihood Rating 1-5	Acres Burned	Average Annual Acres Burned	Average Acres Burned Rating	Total Buildings Damaged	Overall Vulnerability
Franklin	577	64.1	3	1778.80	198	2	10	3
Gasconade	77	8.6	1	846.00	94	1	3	1
Gentry	197	21.9	1	5427.11	603	4	9	3
Greene	560	62.2	2	2525.21	281	3	23	3
Grundy	78	8.7	1	1208.95	134	2	1	2
Harrison	223	24.8	1	8176.41	908	4	8	3
Henry	636	70.7	3	15506.06	1723	5	23	5
Hickory	137	15.2	1	2786.51	310	3	4	3
Holt	133	14.8	1	813.79	90	1	6	1
Howard	87	9.7	1	1542.25	171	2	0	2
Howell	479	53.2	1	8217.45	913	4	265	3
Iron	127	14.1	1	6299.70	700	4	0	3
Jackson	189	21.0	1	288.60	32	1	2	1
Jasper	297	33.0	2	2298.75	255	3	3	3
Jefferson	736	81.8	2	2383.58	265	3	20	3
Johnson	418	46.4	2	1878.20	209	3	4	3
Knox	13	1.4	1	197.50	22	1	0	1
Laclede	410	45.6	2	19800.75	2200	5	7	4
Lafayette	183	20.3	1	921.15	102	2	4	2
Lawrence	430	47.8	2	2326.67	259	3	9	3
Lewis	104	11.6	1	1003.70	112	2	400	2
Lincoln	205	22.8	1	1510.90	168	2	9	2
Linn	99	11.0	1	2614.20	290	3	0	3
Livingston	81	9.0	1	2207.55	245	3	1	3
Macon	120	13.3	1	2133.00	237	3	1	3
Madison	124	13.8	1	867.03	96	1	2	1
Maries	110	12.2	1	3032.70	337	3	2	3
Marion	90	10.0	1	944.45	105	2	0	2
McDonald	163	18.1	1	2152.00	239	3	5	3
Mercer	15	1.7	1	115.85	13	1	0	1
Miller	416	46.2	2	3245.52	361	3	8	3
Mississippi	108	12.0	1	572.00	64	1	1	1
Moniteau	235	26.1	1	1879.76	209	3	3	3
Monroe	130	14.4	1	2234.00	248	3	1	3
Montgomery	140	15.6	1	626.84	70	1	0	1

County	Wildfires 2004-2012	Average Annual # of Wildfires	Likelihood Rating 1-5	Acres Burned	Average Annual Acres Burned	Average Acres Burned Rating	Total Buildings Damaged	Overall Vulnerability
Morgan	570	63.3	3	7255.22	806	4	17	4
New Madrid	93	10.3	1	161.00	18	1	3	1
Newton	1208	134.2	4	4511.29	501	4	53	4
Nodaway	373	41.4	2	5152.73	573	4	12	4
Oregon	425	47.2	2	4819.15	535	4	20	4
Osage	137	15.2	1	982.50	109	2	3	2
Ozark	327	36.3	1	9583.95	1065	5	6	4
Pemiscot	26	2.9	1	70.35	8	1	1	1
Perry	34	3.8	1	490.85	55	1	0	1
Pettis	121	13.4	1	1540.25	171	2	0	2
Phelps	312	34.7	2	3268.90	363	3	6	3
Pike	110	12.2	1	1399.70	156	2	1	2
Platte	52	5.8	1	137.68	15	1	1	1
Polk	366	40.7	1	3332.72	370	3	14	3
Pulaski	266	29.6	1	2597.30	289	3	1	3
Putnam	62	6.9	1	895.48	99	1	0	1
Ralls	51	5.7	1	845.00	94	1	1	1
Randolph	270	30.0	1	2524.95	281	3	3	3
Ray	241	26.8	1	5135.67	571	4	3004	3
Reynolds	372	41.3	2	18070.70	2008	5	7	4
Ripley	284	31.6	1	2858.00	318	3	14	3
Saline	45	5.0	1	1381.35	153	2	0	2
Schuyler	48	5.3	1	970.25	108	2	1	2
Scotland	98	10.9	1	1672.75	186	2	2	2
Scott	281	31.2	1	1703.67	189	2	13	2
Shannon	351	39.0	2	9273.02	1030	5	12	4
Shelby	54	6.0	1	808.20	90	1	2	1
St. Charles	111	12.3	1	690.60	77	1	2	1
St. Clair	430	47.8	2	15593.94	1733	5	13	4
St. Francois	911	101.2	3	7500.88	833	4	12	4
St. Genevieve	216	24.0	1	1069.14	119	2	3	2
St. Louis	66	7.3	1	140.91	16	1	0	1
St. Louis City*	9	1.0	1	1.95	0	1	2	1
Stoddard	368	40.9	2	2172.38	241	3	11	3
Stone	389	43.2	1	3245.63	361	3	5	3

County	Wildfires 2004-2012	Average Annual # of Wildfires	Likelihood Rating 1-5	Acres Burned	Average Annual Acres Burned	Average Acres Burned Rating	Total Buildings Damaged	Overall Vulnerability
Sullivan	44	4.9	1	808.75	90	1	1	1
Taney	554	61.6	1	6218.40	691	4	21	3
Texas	572	63.6	2	6081.81	676	4	19	4
Vernon	130	14.4	1	4308.41	479	3	5	3
Warren	49	5.4	1	178.91	20	1	1	1
Washington	1183	131.4	5	20408.31	2268	5	44	5
Wayne	186	20.7	1	5525.80	614	4	5	3
Webster	325	36.1	2	3262.14	362	3	20	3
Worth	120	13.3	1	6011.77	668	4	1	3
Wright	497	55.2	2	3963.00	440	3	33	3
Totals	**31,988**	**3554.2**	**-**	**476,818**	**52,980**	**-**	**4,463**	**-**

Although the widespread damage associated with wildfire in Missouri is the amount of acreage burned, buildings that are built on or near wildfire prone land, in the Wildland Urban Interface (WUI) are also at risk. For the 9-year period from 2004-2012, a total of 4,463 buildings were reported as damaged by wildfires in Missouri. This translates to an annualized 496 buildings damaged in this 9-year period statewide.

Figure 3.5.11.2 - Vulnerability to Wildfire



According to this analysis, the following counties have a high or medium-high vulnerability rating for wildfire: Benton, Butler, Camden, Crawford, Dallas, Dekalb, Henry, Laclede, Morgan, Newton, Nodaway, Oregon, Ozark, Reynolds, Shannon, St. Clair, St. Francois, Texas, and Washington.

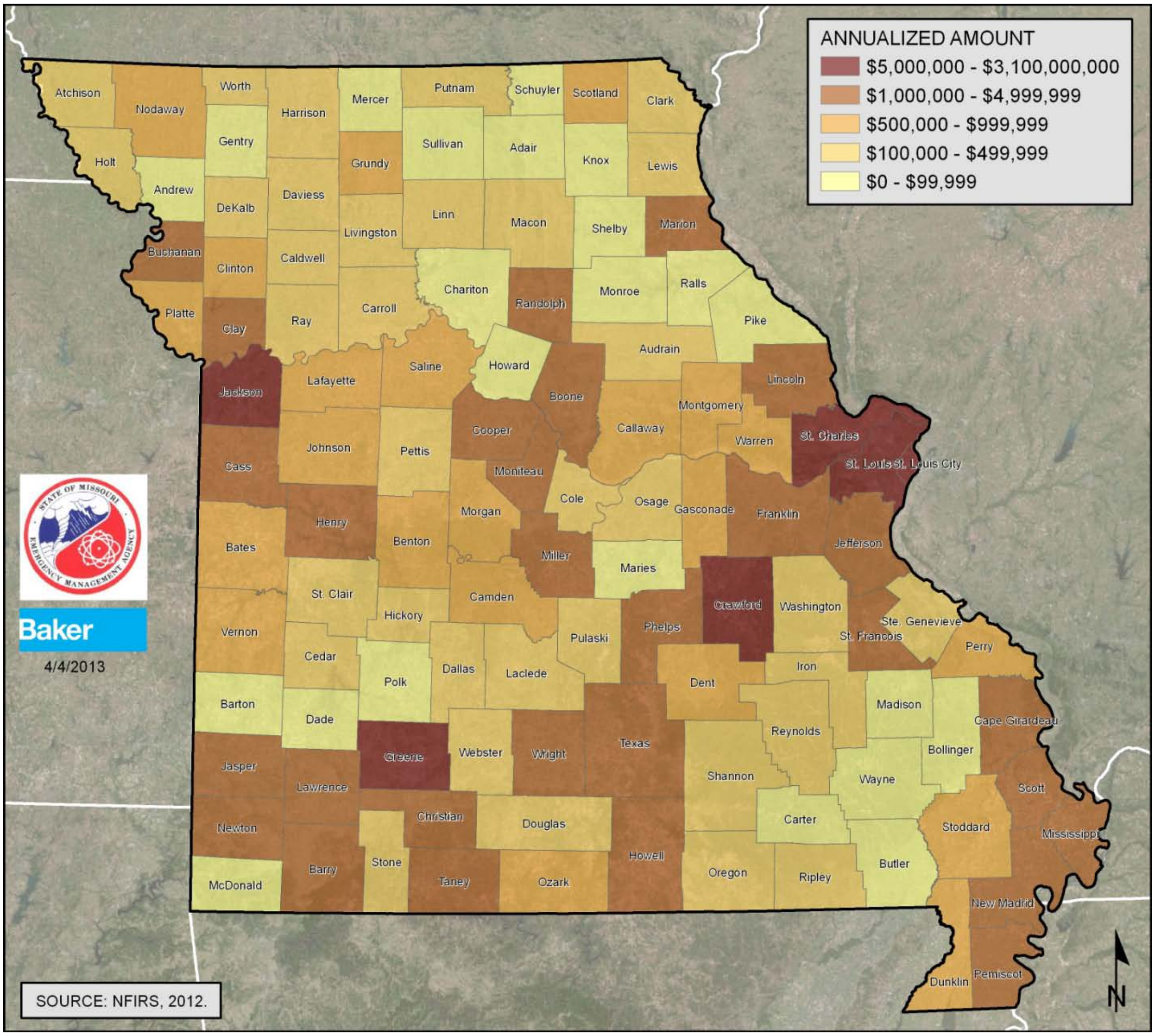
Overview and Analysis of Potential Loss Estimates to Fires

Urban/Structural Fire

Urban/structure fires caused a total of 558 deaths and 3,225 injuries among both civilians and fire service during the 4-year period from 2009-2012. This translates to an annualized occurrence of 140 deaths and 806 injuries statewide. With so many variables involved in death and injury occurrences, it is difficult to predict where future losses will occur.

To determine potential financial loss estimates to urban/structural fire in Missouri, the available historical loss data was annualized. In the case of this type of frequently occurring hazard, annualized historical loss data is considered to be the best resource for determining future potential losses. As shown in the urban/structural fire vulnerability overview analysis section (Figure 3.5.11.3) provides the annualized total property losses for all counties in Missouri.

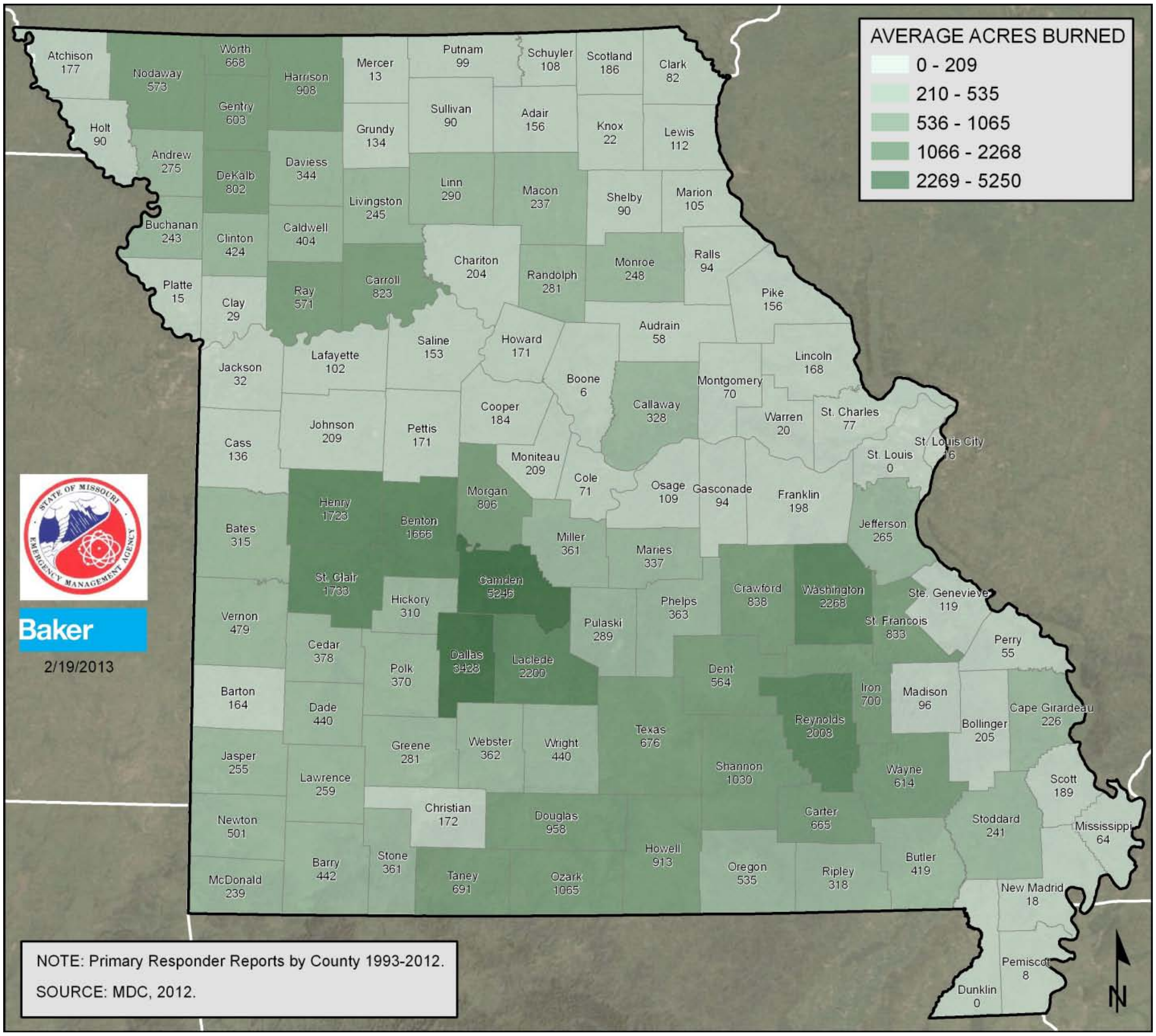
Figure 3.5.11.3 - Annualized Urban/Structural Fire Damages



Wildfire

For the wildfire hazard, the factor considered in determining future potential loss estimates was the annualized acreage burned during the 9-year period from 2004-2012. The available data did not provide an estimated dollar value of the damages reported. Figure 3.5.11.4 that follows depicts the annualized acreage burned for each county in Missouri during this time-frame.

Figure 3.5.11.4 - Annualized Wildfire Damages (Acres Burned)



As mentioned previously, an annualized 4,463 buildings were damaged in the 9-year period statewide. It is anticipated that building damage and the associated potential risk to life of inhabitants will continue.

Changes in Development for Jurisdictions in Hazard Prone Areas

Of the top 10 counties vulnerable to urban/structural fire according to this statistical analysis methodology, five also had population increases over 12,000 from 2000-2010: Greene, Jackson, Jasper, Jefferson, and St. Charles. Of the top 10 vulnerable counties, 5 also had increases in housing units over 11,000: Greene, Jackson, Jefferson, St. Charles, and St. Louis (US Census, 2010).

None of the top 10 counties vulnerable to wildfire had population increase over 12,000 or housing unit increase over 11,000.

3.5.12 CBRNE Attack (Chemical, Biological, Radiological, Nuclear and high yield Explosive)

For hazard profile information for attack, see Section 3.3.12.

Overview and Analysis of Vulnerability to Attack

A strategic CBRNE (chemical, biological, radiological, nuclear, and high yield explosive) attack on the United States could have the most devastating and far-reaching consequences. The use of these weapons against the United States is unlikely. Unfortunately, however, as long as such weapons exist, there is always a chance that they could be used. The potential for traditional war-related attacks, using conventional weapons, is a scenario that is more likely to occur, based on currently available information, however even attacks of that variety are rare. Attackers are likely to have either very specific targets such as Women's clinics, or desire large publicity from the attacks.

It is not possible to calculate a specific vulnerability for each county in Missouri. However, because of the desire for publicity following attacks, it is more likely that counties with greater population densities would be the target of attacks. Sparsely populated rural counties are less desirable targets for publicity-seeking terrorists. It is expected that the likelihood of attack is directly related to population density or more likely to an event that is occurring or to a specific location of importance to the attacker. For example, a large venue event, such as a sporting event attended by tens of thousands of people might be considered a desirable target. Most large public venues occur in densely populated areas since those areas are able to provide the infrastructure support (hotels, eateries, etc.) for large numbers of people. A description of population density is contained in this plan in Section 3.4.

Overview and Analysis of Potential Loss Estimates to Attack

Potential losses for this hazard include all infrastructure, critical facilities, humans and animals. The degree of impact would be directly related to the type of CBRNE incident. Potential losses would include cost of repair or replacement of damaged facilities, lost economic opportunities for businesses, loss of human life, and injuries to persons. Secondary effects of infrastructure failure could include public safety hazards, spread of disease, increased morbidity and mortality among the local and distant populations and public panic. CBRNE events are rare occurrences and specific amounts of estimated losses for previous occurrence are not available due to the complexity and multiple variables associated with these types of hazards.

As discussed previously, it is difficult to quantify potential losses in terms of the jurisdictions most threatened by CBRNE attack events due to the many variables and human element that come into play. Therefore, for the purposes of this plan, the loss estimates will take into account several hypothetical scenarios. Please note that these hypothetical scenarios are included to provide a sample methodology for local jurisdictions to estimate potential losses. The hypothetical scenarios include: a chemical attack, a biological attack, an IED attack, and a radiological attack. For comparative purposes, these hypothetical attack scenarios will all be staged at the same venue, a baseball game at a large stadium. The hypothetical stadium is situated on less than one square mile and has a seating capacity of over 45,000 persons. Surface area and parking structures are located adjacent to the stadium.
Analysis of vulnerable populations is aided by a program developed by Johns Hopkins University in 2006 called Electronic Mass Casualty Assessment and `Planning Scenarios (EMCAPS)[68] which utilizes scenarios put together by the Department of Homeland Security.

[68] http://www.hopkins-cepar.org/EMCAPS/EMCAPS.html

****THE FOLLOWING HYPOTHETICAL SCENARIOS ARE FOR INSTRUCTIONAL AND ILLUSTRATIVE PURPOSES ONLY****

Chemical Attack – Mustard Gas

Scenario Overview: Mustard gas is released from a light aircraft onto a stadium during a sporting event. The agent directly contaminates the stadium and the immediate surrounding area. This particular type of attack would cause harm to humans and could render portions of the stadium unusable for a short time period in order to allow for a costly clean-up. There might also be a fear by the public of long-term contamination of the stadium and subsequent boycott of games resulting in a loss of revenue and tourism dollars.

Assumptions: (1) The population density at the stadium on game day is high – approximately 75 percent of the seats, 31,000, are filled. (2) Sulphur mustards are extremely toxic and may damage eyes, skin and respiratory tract. Death sometimes results from secondary respiratory infections. (3) The rate of "worried well" is equal to 9 times the number of infected cases.

Described Losses:

Severe Eye Injuries (1-2 hours)	23,250 persons
Severe Airway Injuries (1-2 hours)	23,250 persons
Severe Skin Injuries (2 hrs to days)	27,900 persons
Total "Worried Well" Cases (9 times the number of affected cases)	251,000 persons
Deaths	620 persons

Notes: Victims will require decontamination and both long and short term treatment. Services may need to be suspended at the area until all investigations are conducted.

Biological Attack – Pneumonic Plague

Scenario Overview: Canisters containing aerosolized pneumonic plague bacteria are opened in public bathrooms. Each release location will directly infect 110 people; hence, the number of release locations dictates the initial infected population. The secondary infection rate is used to calculate the total infected population. This particular weapon of mass destruction (WMD) attack method would not cause damages to buildings or other infrastructure, only to human populations.

Assumptions: (1) The population density at the stadium on game day is high. (2) The population density of the stadium city is high (5,724 persons / sq mile). (3) The number of dispersion devices is 30. Devices are assumed to be placed in crowded seating areas. (4) Pneumonic plague has a 1-15 percent mortality rate in treated cases and a 40-60 percent mortality rate in untreated cases. (5) The rate of "worried well" is equal to 9 times the number of infected cases.

Described Losses:

Initial Infected Populations	3300 persons
Secondary Infected Population	16,629 persons
Total Plague Cases	19,929 persons
Total Deaths (Treated Cases 7%)	1,395 persons
Total "Worried Well" Cases (9 times the number of infected cases)	179,361 persons

Improvised Explosive Device Attack – ANFO

Scenario Overview: An Improvised Explosive Device (IED) utilizing an ammonium nitrate/fuel oil (ANFO) mixture is carried in a panel van to a parking area during a time when stadium patrons are leaving their cars and entering the stadium and detonated. Potential losses with this type of scenario include both human and structural assets.

Assumptions: (1) The population density in the parking lot during the beginning and ending of the games is high, at least 1 person /50 square feet. (2) The quantity of ANFO used is 4,000 lbs, similar to that used by Timothy McVeigh in the Oklahoma City bombing. (3) The Lethal Air Blast Range for such a vehicle is 200 feet according to the Bureau of Alcohol, Tobacco, Firearms and Explosives (BATF) Standards. (4) The Falling Glass Hazard distance is 2,750 feet according to BATF Explosive Standards.

Described Losses:

Total Dead	695 persons
Total Traumatic Injuries	1,218 persons
Total Urgent Care Injuries	5,967 persons
Injuries not Requiring Hospitalization	2,233 persons
Structures and Other Physical Assets (Damages would certainly occur to vehicles and depending on the proximity of other structures, damages would occur to the stadium complex itself. The exact amount of these damages is difficult to predict because of the large numbers of factors, including the type of structures nearby and the amount of insurance held by vehicle owners.)	Vehicles – Replacement cost for approximately 100 vehicles @ $15,000 per vehicle inside the 200 ft BATF described Lethal Air Blast range = $ 150,000 Repair / repainting cost for approximately 500 vehicles @ $ 4,000 per vehicle inside the BATF described Falling Glass Hazard = $2,000,000

Radiological Dispersion Device – Dirty Bomb Attack

Scenario Overview: An Improvised Explosive Device (IED) utilizing an ammonium nitrate/fuel oil (ANFO) mixture is carried in a panel van to a parking area during a time when stadium patrons are leaving their cars and entering the stadium and detonated. Potential losses with this type of scenario include both human and structural assets. The bomb also contains 2,700 Curies of Cesium-137 (Cs-137).

Assumptions: (1) The population density in the parking lot during the beginning and ending of the games is high, at least 1 person /50 square feet. (2) The quantity of ANFO used is 4,000 lbs, similar to that used by Timothy McVeigh in the Oklahoma City bombing. (3) The Lethal Air Blast Range for such a

vehicle is 200 feet according to the Bureau of Alcohol, Tobacco, Firearms and Explosives (BATF) Standards. (4) The Falling Glass Hazard distance is 2,750 feet according to BATF Explosive Standards.

Described Losses:

Total Dead	695 persons
Total Traumatic Injuries	1,218 persons
Total Urgent Care Injuries	5,967 persons
Injuries not Requiring Hospitalization	2,233 persons
Radiological Poisoning Injuries that Need Aggressive Treatment	6
Radiological Poisoning Injuries that Need Non-Critical Treatment	220
Radiological Poisoning Injuries that could Self Medicate with Proper Public Information	31,188
Structures and Other Physical Assets (Damages would certainly occur to vehicles and depending on the proximity of other structures, damages would occur to the stadium complex itself. The exact amount of these damages is difficult to predict because of the large numbers of factors, including the type of structures nearby and the amount of insurance held by vehicle owners.)	Vehicles – Replacement cost for approximately 100 vehicles @ $15,000 per vehicle inside the 200 ft BATF described Lethal Air Blast range = $ 150,000 Repair / repainting cost for approximately 500 vehicles @ $ 4,000 per vehicle inside the BATF described Falling Glass Hazard = $2,000,000

Changes in Development for Jurisdictions in Hazard Prone Areas

As more and more large public events are held in Missouri, more potential may exist for these venues to become targets of attack. However, with manmade hazards such as this that can have multiple variables involved increases in development is not necessarily always a factor in determining risk.

3.5.13 Civil Disorder

For hazard profile information for civil disorder, see Section 3.3.13.

Overview and Analysis of Vulnerability to Civil Disorder

Although it is a rare event, when rioting does break out, it generally proves extremely difficult for first-responder law enforcement authorities to quell the mob promptly. Initial police presence is often undermined because forces may be staffed below the peak loads needed to bring things back under control. As a result, the riot may continue until enough state police or National Guard units arrive to bolster the arrest process and subsequently restore order. In many cases, damage to life and property may already be extensive. Civil disorder could occur when any large crowd of persons gather. These disorders can have political, social or other causes making it difficult to determine when and where they will occur.

Overview and Analysis of Potential Loss Estimates to Civil Disorder

While it is not possible to predict the location of civil disorders, those locations with correctional facilities are historically more likely to be susceptible to such incidents. Listed in Table 3.5.13a are the counties in which there is a correctional center. These counties are determined to have a high risk and all other counties are determined to have a low risk. The cost of a response and recovery from a civil disorder is difficult to determine, and can range from minor damages to millions of dollars.

Table 3.5.13a Missouri Counties with Correctional Centers

County	Correctional Facility
Audrain County	Women's Eastern Reception, Diagnostic, and Correctional Center
Buchanan County	Western Reception, Diagnostic, and Correctional Center
Callaway County	Fulton Reception & Diagnostic Center
Clinton County	Crossroads Correctional Center
Clinton County	Western Missouri Correctional Center
Cole County	Algoa Correctional Center
Cole County	Central Missouri Correctional Center
Cooper County	Booneville Correctional Center
DeKalb County	Crossroads Correctional Center
Dekalb County	Western Missouri Correctional Center
Franklin County	Missouri Eastern Correctional Center
Jackson County	Kansas City Community Release Center
Livingston County	Chillicothe Correctional Center
Mississippi County	Southeast Correctional Center
Moniteau County	Tipton Correctional Center
Nodaway County	Maryville Treatment Center
Pike County	Northeast Correctional Center
Ralls County	Women's Eastern Reception, Diagnostic, and Correctional Center

County	Correctional Facility
Randolph County	Moberly Correctional Center
St. Francois County	Eastern Reception & Diagnostic Center
St. Francois County	Farmington Correctional Center
St. Francois County	Missouri Eastern Correctional Center
Texas County	South Central Correctional Center
Washington County	Potosi Correctional Center
Webster County	Ozark Correctional Center

Source: Missouri Department of Corrections

Changes in Development for Jurisdictions in Hazard Prone Areas

Prison construction in Missouri, as in many other states, was a growth industry during the 1980s and early 1990s. With the added prison capacity, the number of offenders incarcerated in the Missouri Department of Corrections (DOC) grew from 19,266 in 1995 to 28,567 in 2001. This growth seemed to have no end until a tightening state budget and competing priorities signaled an end to new prison construction. According to several sources, Missouri's prison population has reached an all-time high. The cause of the increase in inmates is unknown, but contributing factors include: changes in funding, the economy, and higher crime and conviction rates.

3.5.14 Cyber Disruption

For hazard profile information for cyber disruption, see Section 3.3.14.

Overview and Analysis of Vulnerability to Cyber Disruption

Cyber disruptions have the potential to undermine the confidence that people have in their own security when dealing with any number of cyber systems. Intentional events would also succeed in building doubt in their government's ability to protect them from harm. The potential for a major cyber disruption, through intentional attacks, is the scenario that is more likely to occur, based on currently available information. Attacks of that variety are minimal, though increasing in frequency as the threat evolves. Attackers are likely to have either very specific targets, or desire wide-spread publicity from the attacks that would lead towards the targeting of popular, iconic, or critical systems.

Overview and Analysis of Potential Loss Estimates to Cyber Disruption

Thought a Cyber Disruption can have limited impacts within a system's own operations, it also can have extended cascading affects throughout multiple systems. Potential loss is difficult to quantify and can only be hypothetically considered. The system that is disrupted and the source of the disruption are major factors in the impact. If it is an intentional disruption and the system is critical then the impact has the potential to quite devastating.

Some examples of cyber disruption losses include:

- Failure of a medical research database: This would be a localized event that would most likely have minimal losses associated with it, as long as there are adequate data backup systems in place. Losses would be staff time since last data backup and resources needed to be replaced. The magnitude could be estimated to be in the range of hundreds to thousands of dollars, with no injuries or losses to life.
- Government intranet failure due to hardware: This would also be fairly localized, though external users could also be impacted. Hardware failures are typically able to be replaced within a day or two. Losses would depend on the functionality that is lost while the system is down. Assuming the site is used for general information, inquiries, and some on-line data transactions, the magnitude could be estimated to be in the range of hundreds to thousands of dollars, with no injuries or losses to life.
- Breach of sensitive database for the justice offices: This type of event could have broad-reaching effects, depending on if and how the breached data is utilized and whether the public is made aware. Potential losses would be influenced not so much by the event itself, but rather the government's reaction to the event. A partial or complete rebuild of the system and its security processes would occur. In addition, increased security for individual's impacted, as well as resources deployed to identify and prosecute those responsible. A loss of public trust could also entail necessary changes to processes and resources spent to assure the public and re-brand the agency. The magnitude of this type of event could be estimated to be in the range of tens to hundreds of thousands of dollars. Specifically-targeted injuries or deaths could result for those whose personal information was revealed.
- Utility services remotely accessed and controlled: This event would be on the scale of a worst-case situation that could have wide-ranging impacts. Losing direct control of any type of utility could have far-reaching impacts to the safety of the public as well as the functionality of any related systems. This domino effect could negatively influence the daily life activities of the

public and could take government services completely off-line. Public safety could be put at risk. This type of event could produce the same impacts as a worse-case natural hazard. The magnitude of losses for this event could reach upwards of millions to billions of dollars. Large scale injuries or deaths could be expected to occur.

As discussed previously, it is difficult to describe vulnerability in terms of the systems most threatened by cyber disruptions due to the many variables and human elements that come into play.

Changes in Development for Jurisdictions in Hazard Prone Areas

As the populace and infrastructure within Missouri increasingly rely on cyber systems in daily operations, the risk for cyber disruption will only increase. This is a newly developing threat so as more resources are devoted to countering the hazard; the risk to a disruption would hopefully decrease. As infrastructure and facilities are upgrade while new development occurs, planners will need to keep in mind the potential for disruption to essential services due to cyber disruption.

3.5.15 Hazardous Materials Release (Fixed Facility Accidents/Transportation Accidents)

For hazard profile information for hazardous materials release, see Section 3.3.15.

Overview and Analysis of Vulnerability to Hazardous Materials Release

Every day, hundreds of trucks with chemical tanks traverse the State on the thousands of streets, roads, and highways. Every day, dozens of chemical cargos cross the State on the railroads. These trucks and railcars constitute potential hazards on wheels. In addition, every day, the fixed facilities that store and use chemicals have the potential for accidents. During an accidental release of toxic chemicals or other emergencies where air quality is threatened, the toxics heavier than air settle on the ground and the people in proximity can breathe these toxics and be affected; the toxics lighter than air spread for several miles and impact distant people.

The State of Missouri has seven environmental emergency response and hazardous waste disposal companies currently under state contract to provide services to the department as needed. Use of the contract is mandatory for all state government agencies and optional for all local governmental agencies. Some of the contractors provide services only to specific parts of Missouri and others provide services statewide. Services available from the contract include emergency response, including personnel and specialized equipment, on-site technical management of clean-up activities and disposal of hazardous wastes. This hazard could have a significant impact on the public health, the environment, private property, and the economy.

Overview and Analysis of Potential Loss Estimates to Hazardous Materials Release

The impact of this type of disaster will likely be localized to the immediate area surrounding the incident. The initial concern will be for people, then the environment. If contamination occurs, the spiller is responsible for the cleanup actions and will work closely with the Missouri Department of Natural Resources, EPA, and the local jurisdiction to ensure that cleanup is done safely and in accordance with federal and state laws.

As mentioned, it is difficult to determine the potential losses to existing development because of the variable nature of a hazardous materials spill. For example, a spill of a toxic airborne chemical in a populated area could have great potential for loss of life and by contrast, the spill of a very small amount of a chemical in a remote agricultural area where remediation of soil would be easier could be less costly.

For the purposes of this discussion, the materials needed for a very small spill of a less hazardous chemical in an easily remediated area are listed below in Table 3.5.15a. The cost for the essential personnel and equipment are taken from the current State of Missouri contract for Hazardous Substance Cleanup and Disposal Services (C307154001-C307154004).

Table 3.5.15a Potential Cost Estimate for HAZ-MAT Spill Remediation

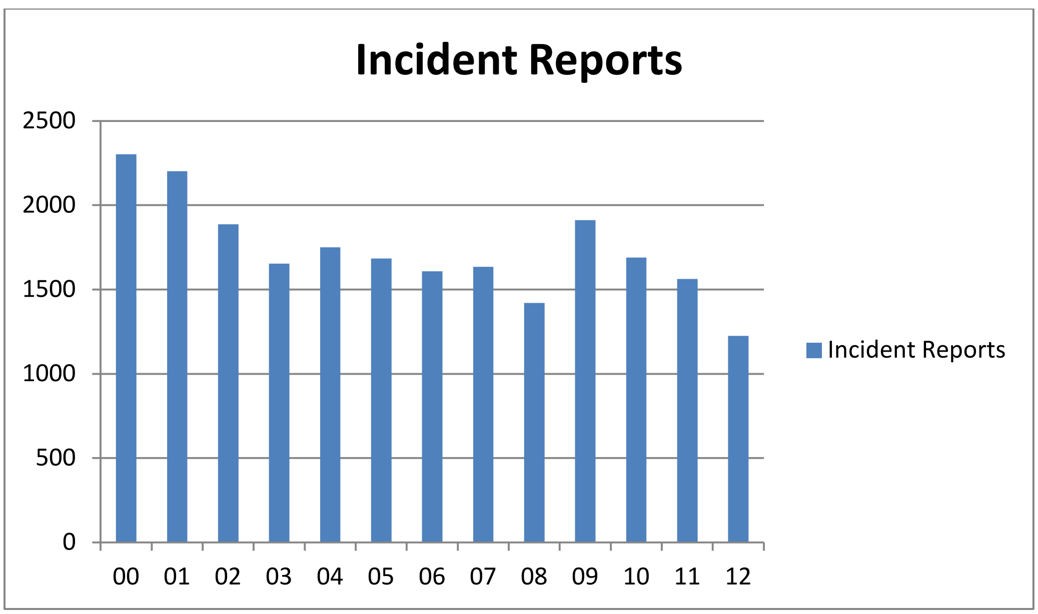
Associated Costs:	Cost per hour/unit	Number of Hours/Units	Total Cost
Project Manager	$86.00	8	$688.00
Equipment Operator	$67.25	8	$538.00
Response Vehicle	$25.00	8	$200.00

Associated Costs:	Cost per hour/unit	Number of Hours/Units	Total Cost
Track Hoe	$50.00	8	$400.00
Environmental Tech	$56.75	8	$454.00
Chemical Suit	$185.00	6	$1,110.00
Duct tape	$8.00	6	$48.00
Sampling Tubes	$3.00	20	$60.00
Gloves	$10.00	12	$120.00
PVC Rubber Boots	$30.00	6	$180.00
Vermiculite (19 lb. bag)	$16.00	4	$64.00
55 Gallon Drum	$50.00	20	$1,000.00
95 Gallon Overpack Drum	$250.00	20	$5,000.00
Total			**$9,862.00**

Source: The cost for the essential personnel and equipment are taken from the current State of Missouri contract for Hazardous Substance Cleanup and Disposal Services (C307154001-C307154004)

The planning team also obtained information from the Missouri Department of Natural Resources Environmental Emergency Response Field Services Section. The Fiscal Year 2012 Incident Summary Report summarizes hazardous substances emergencies/releases reported to the Missouri Environmental Emergency Response Tracking System (MEERTS) http://www.dnr.mo.gov/env/esp/meerts.htm. According to DNR, during the last 12 years, Emergency Response has received an average of 1,733 incidents each year. Figure 3.5.15.1 provides the yearly incidents reported during this time period.

Figure 3.5.15.1 - Hazardous Substances Emergencies/Releases Reported to MEERTS (2000-2012)



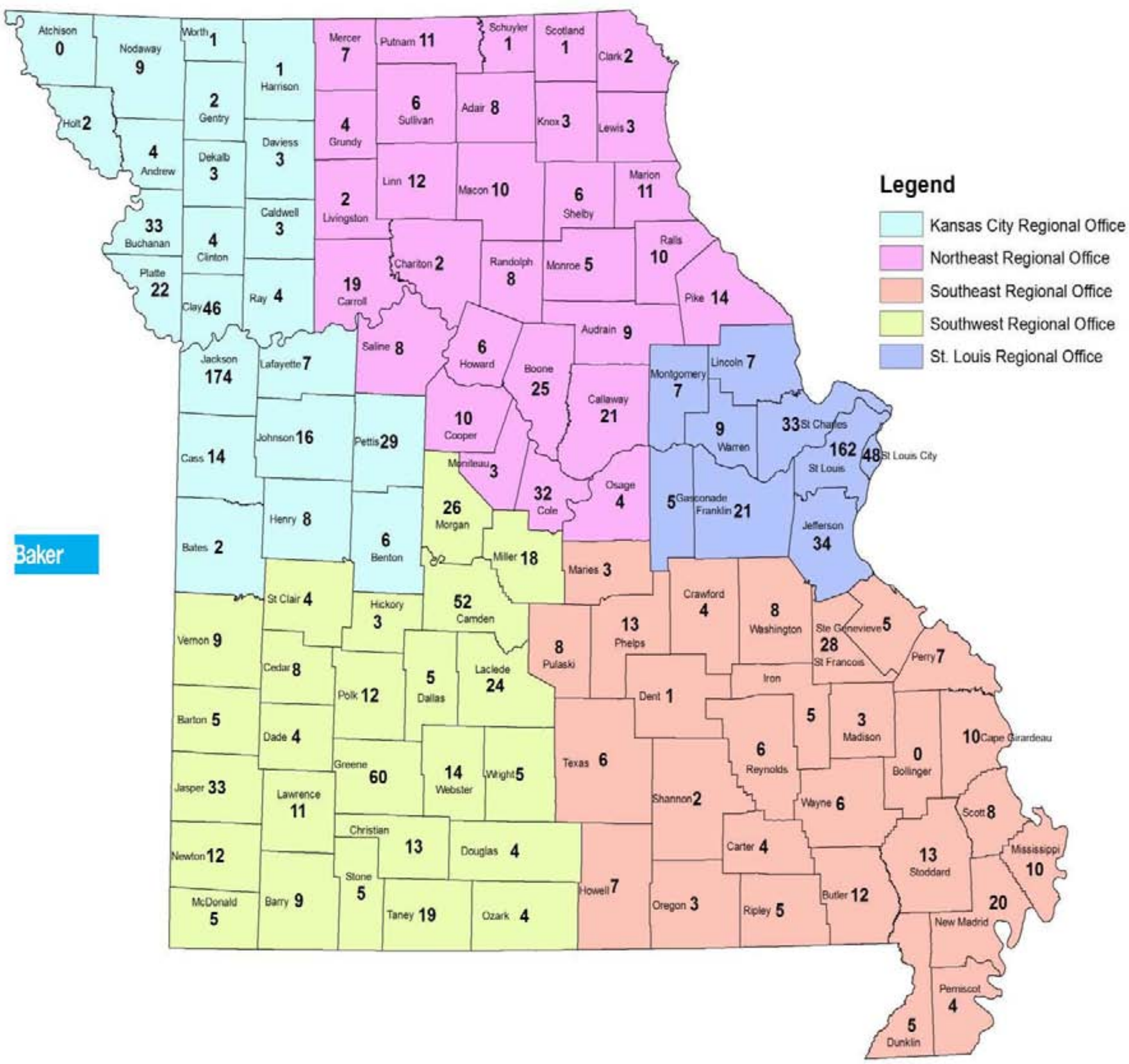
Source: Missouri Department of Natural Resources Environmental Emergency Response Field Services Section Fiscal Year 2012 Incident Summary Report

To estimate a potential cost, the estimated $9,862 cost per incident was then applied to the average annual number of reported incidents of 1,733 to calculate an average annual minimal cost. The annual

cost of remediation of spills is calculated as follows: 1,733 average annual incidents X $9,862 per incident = $17,090,846. The majority of the cost of chemical clean-ups is borne by the party responsible for the spill, in some instances private, for-profit companies.

Figure 3.5.15.2 provides the number of reported incidents for each county in Missouri for Fiscal Year 2011. During this year, there were a total of 1,563 total reported incidents. This level of detailed data was not available for years prior to 2009.

Figure 3.5.15.2 - Fiscal Year 2011 Reported Hazardous Substances Emergencies/Releases Incidents



Source: Missouri Department of Natural Resources Environmental Emergency Response Field Services Section Fiscal Year 2011 Incident Summary Report;

Note: Colored regions indicate the five DNR Emergency Response Regional Offices, does not include methamphetamine incidents.http://dnr.mo.gov/env/esp/docs/all-incidents-reported-map-2011.pdf

Because the nature of this hazard is so variable, it is difficult to create a potential dollar loss estimate for each county or for any geographic region. The damage that would be expected would be based on the type of chemical released, weather conditions, location of the spill, size of the spill, etc.

Changes in Development for Jurisdictions in Hazard Prone Areas

As the infrastructure and population of Missouri increase along with the number and type of hazardous chemicals stored and transported through the State, the amount of potential losses will increase. Because of the nature of the hazard, it is not possible to determine a geographic variability in future potential loss.

3.5.16 Mass Transportation Accidents

For hazard profile information for mass transportation accidents, see Section 3.3.16.

Overview and Analysis of Vulnerability to Mass Transportation Accidents

A major accident can occur at any time, even though safety precautions are in place. Missouri serves as transportation crossroads for the United States. Branson, Missouri, which is located close to the State's southwestern border, has become a major tourist attraction. Because Branson is a small community, tourists represent a large portion of the population. To meet the needs posed by the large number of tourists, the city has been expanding its services (number of hospital beds, fire equipment, ambulances, etc.) and is able to provide more assistance than other communities of its size. A mass transportation accident could burden a local jurisdiction's available medical services.

Overview and Analysis of Potential Loss Estimates to Mass Transportation Accidents

It is difficult to determine the actual risk to each county in Missouri. No specific mass transportation studies have been conducted to date. Certainly the counties in and surrounding the metropolitan areas of St. Louis, Springfield and Kansas City are at greater risk because of the nature of the population and the transportation hubs within each area. The Branson area would also have a greater risk because of the large numbers of tourists visiting the area and arriving by mass transportation. However, an accident could occur in any area in Missouri. According to the National Safety Council's Injury Facts, 2011 Edition, the cost of all motor vehicles deaths and disabling injuries for 2009 was $244.7 billion nationally. This included the costs that every household pays whether directly out of pocket, or through higher prices for goods and services or through higher taxes. The US Department of Transportation Federal Highway Administration issued a technical advisory in 1994 providing suggested estimates of the costs of traffic crashes to be used by states for planning. These figures have been converted from 1994 dollars to 2011 dollars. Those costs are listed below in Table 3.5.16a. Although there are other types of mass transportation accidents, the traffic accident was chosen for the loss estimate scenario since it is the most common mass transportation accident. Loss estimation scenarios for rail, airways, and waterways could also be developed. However, since these types of events have wide-range variables, it would be difficult to develop a "typical" loss scenario.

Table 3.5.16a Costs of a Traffic Crash

Severity	Cost per Injury (in 2011 dollars $)
Fatal	$2,810,212
Incapacitating Injury	$ 268,912
Evident Injury	$ 53,782
Possible Injury	$ 28,385
Property Damage Only	$ 2,988

Source: Department of Transportation Federal Highway Administration Technical Advisory T7570.2, 1994. Adjusted to 2011 dollars.

Using the Missouri Department of Transportation's 2011 Missouri State Highway System Traffic Crash Statistics as a basis for the number of vehicle crashes and the Federal Highway Administration's costs of a traffic crash, a potential loss estimate has been calculated. The crash numbers are for 2011 and it is assumed that 2011 was a typical year for crashes. Based on these assumptions, Table 3.5.16b lists the

potential costs associated with mass transportation accidents in Missouri. It is assumed that injuries are evident injuries rather than incapacitating injuries.

Table 3.5.16b Annual Loss Estimates for Mass Transportation Accidents (Vehicle Accidents)

Vehicle Type	Total Injuries	Total Fatalities	No of Property Damage Only Crashes	Associated Costs (2011 dollars)
Bus	211	3	891	$58,080,946
Limousine	8	0	49	$2,536,668
School Bus	116	1	669	$37,807,896
Van	4,002	61	11,687	$889,059,756
TOTAL				**$987,484,762**

Source: *2011 Missouri Traffic Safety Compendium*, Missouri State Highway Patrol Statistical Analysis Center, 2011.

Changes in Development for Jurisdictions in Hazard Prone Areas

As the amount of tourism increases and personal travel through Missouri via mass transit increases, the number of accidents can be expected to increase. Costs increase each year as well.

3.5.17 Nuclear Power Plants (Emergencies and Accidents)

For hazard profile information for nuclear power plants, see Section 3.3.17.

Overview and Analysis of Vulnerability to Nuclear Power Plant Emergencies and Accidents

An accident involving radioactive materials could occur in Missouri from a variety of sources: nuclear reactors, transportation accidents (see Section 3.3.15 Hazardous Materials), industrial and medical uses, and lost or stolen sources where the public could be exposed, or contaminated, with a high level of radiation. Although the chance of a nuclear power plant release is unlikely, radiological accidents can cause injury or death, contaminate property and valuable environmental resources, as well as disrupt the functioning of communities and their economies.

Overview and Analysis of Potential Loss Estimates to Nuclear Power Plant Emergencies and Accidents

Local and state governments, federal agencies, and the electric utilities have emergency response plans in place in the event of a nuclear power plant incident. The plans define two "emergency planning zones." One zone covers an area within a 10-mile radius of the plant, where it is possible that people could be harmed by direct radiation exposure. The second zone covers a broader area, usually up to a 50-mile radius from the plant, where radioactive materials could contaminate water supplies, food crops, and livestock.

The potential danger from an accident at a nuclear power plant is exposure to radiation. This exposure could come from the release of radioactive material from the plant into the environment, usually characterized by a plume (cloud-like formation) of radioactive gases and particles. The major hazards to people in the vicinity of the plume are radiation exposure to the body from the cloud and particles deposited on the ground, inhalation of radioactive materials, and ingestion of radioactive materials.

There are several Missouri counties included in 10-mile and 50-mile emergency planning zones (EPZ) for nuclear power plants. There are two commercial plants that could pose a threat to Missouri: The Callaway Nuclear Generating Station in Callaway County and the Cooper Nuclear Station in Nemaha County, Nebraska. There are also Missouri University of Science and Technology research reactors that support education, research, training, and regional industries. Those maps in Section 3.3.17 illustrate counties impacted by nuclear power plant emergency planning or the university reactor.

Counties within the 10-mile EPZ for commercial nuclear power plants have a relatively higher radiological risk than other counties, but the potential for an incident is extremely low. These counties include portions of Callaway, Osage, and Montgomery for the Callaway plant, and Atchison and Holt for the Cooper plant. Counties within the 50 mile ingestion pathway are at lower risk. For the Cooper plant, those counties include Andrew County and Nodaway County, in addition to those in the 10 mile EPZ. For the Callaway plant, counties within the 50 mile ingestion pathway include Audrain County, Boone County, Crawford County, Cole County, Cooper County, Franklin County, Gasconade County, Howard County, Lincoln County, Maries County, Miller County, Monroe County, Moniteau County, Pike County, Randolph County, Ralls County, St. Charles County, and Warren County.

Changes in Development for Jurisdictions in Hazard Prone Areas

None of the counties within the 10 mile EPZ for the Cooper or Callaway plants are in the top 10 counties for housing unit and population gains. Boone and St. Charles Counties are within the 50 mile ingestion pathway for the Callaway plant and are among the top 10 counties for housing and population gains from 2000 to 2012. Lincoln County, in the Callaway 50-mile ingestion pathway is in the top 10 for population gains.

3.5.18 Public Health Emergencies/Environmental Issues

For hazard profile information for public health emergencies/environmental issues, see Section 3.3.18.

Overview and Analysis of Vulnerability to Public Health Emergencies/Environmental Issues

Public Health Emergencies

All of Missouri is at risk to public health emergencies. There are a few special populations that are at increased risk for infectious diseases. Those special populations include: the institutionalized elderly, prison populations and children, especially un-immunized children (for vaccine preventable diseases). The Missouri DHSS reports that in November 2012 there were a total of 1,143 licensed adult care homes in Missouri with a census of 54,740 persons. The total available licensed adult care home beds for the State was 78,039. http://health.mo.gov/seniors/nursinghomes/pdf/BEDCENSUS.pdf.

The Missouri Department of Elementary and Secondary Education indicates that in 2012 there were 885,630 children enrolled in elementary and secondary education institutions. http://mcds.dese.mo.gov/quickfacts/District%20and%20School%20Information/District%20Enrollment%20by%20Grade.xls Vaccine preventable diseases are rare, but they do occur. The consequences of vaccine preventable childhood diseases can be quite serious and include liver damage, hearing loss, blindness, coma and death. Childhood immunization rates are fairly high for Missouri yet approximately 8 to 27 percent are not adequately immunized against certain diseases (CDC, 2011). Childhood immunizations are safe with only minimal side effects of pain, redness and swelling at the injection site, compared to the horrible consequences of the diseases themselves. The U.S. National Immunization Survey for 2011 showed Missouri below the nation in some requirements. Some data from the survey is displayed in Table 3.5.18a below. http://www.cdc.gov/vaccines/stats-surv/nis/articles.htm#11. Each column represents a particular type of vaccination and the percentage of the population that have received it.

Table 3.5.18a Estimated vaccination coverage for the 4:3:1:3:3:1 and 4:3:1:3:3:1:4 vaccination series and selected individual vaccines among children aged 19--35 months (N = 18,430)

Country/State	≥3 Hib	≥1 HepB (birth)	≥4 PCV	≥2 HepA	4:3:1:3:3:1	4:3:1:3:3:1:4
United States	90.0	68.6	84.4	52.2	71.0	68.5
Missouri	90.0	72.9	79.2	46.5	72.7	67.6

National Immunization Survey (NIS), United States, 20011§

Environmental Issues

Although Missouri has never had an environmental disaster of large proportions, there are many instances where hazardous substances can impact the environment with considerable consequences to either air or water. Floods often temporarily interrupt community water supplies, creating the need for emergency potable water for thousands of people. In July 1993, for example, St. Joseph's municipal water plant was forced to shut down for an extended period when contaminated floodwater threatened to enter the system. Floodwaters also disrupt wastewater treatment facilities, resulting in the discharge of raw or improperly treated sewage. Periodically, water pollutants cause fish kills in Missouri streams, and excessive air pollutants associated with smog in large metropolitan areas create public health problems.

Overview and Analysis of Potential Loss Estimates to Public Health Emergencies/ Environmental Issues

Public Health Emergencies

Buildings, infrastructure, and critical facilities are not vulnerable to this hazard. It affects only persons susceptible to the illness. The lasting impacts and potential losses are largely economic and are dependent on the type, extent, and duration of the illness. There is no data currently available on the economic impact of previous pandemic illness in Missouri. Using pandemic influenza as the worst case scenario for estimating potential losses, the Missouri Department of Health and Senior Service's Pandemic Influenza Planning includes the following assumptions about pandemic disease in Missouri. The clinical disease attack rate would be 30 percent in the overall population. Of those who become ill with influenza, 50 percent will seek medical treatment.

Using the Missouri DHSS planning assumptions and further assuming that 2 percent of those seeking medical care would require hospitalization the chart below lists the potential number of hospital admissions by county. The Missouri Bureau of Health Care Analysis and Data Dissemination provided hospital charges and total patient discharges related to Respiratory Infections, This data was used to determine typical hospital charges for each hospitalized victim. Rankings of vulnerability were assigned based on potential hospital charges as follows: $0 to $250,000 = Very Low, $250,001 - $500,000 = Low, $500,001 - $750,000 = Medium, $750,001 - $1,000,000 = High and greater than $1,000,000 = Very High. Table 3.5.18b below displays the results of the analysis and Figure 3.5.18.1 portrays this analysis in a statewide map.

Table 3.5.18b Potential Vulnerability of Missouri Counties for Pandemic Influenza

County	2010 Population Estimate	Potentially Affected Population	Potential Number of Persons Seeking Medical Care	Potential Number Hospitalized	Potential Charges in Dollars	Vulnerability
St. Louis County	998,954	299,686	149,843	2,997	$63,713,285	Very High
Jackson County	674,158	202,247	101,124	2,022	$42,997,780	Very High
St. Charles County	360,485	108,146	54,073	1,081	$22,991,733	Very High
St. Louis city	319,294	95,788	47,894	958	$20,364,571	Very High
Greene County	275,174	82,552	41,276	826	$17,550,598	Very High
Clay County	221,939	66,582	33,291	666	$14,155,269	Very High
Jefferson County	218,733	65,620	32,810	656	$13,950,791	Very High
Boone County	162,642	48,793	24,396	488	$10,373,307	Very High
Jasper County	117,404	35,221	17,611	352	$7,488,027	Very High
Franklin County	101,492	30,448	15,224	304	$6,473,160	Very High
Cass County	99,478	29,843	14,922	298	$6,344,707	Very High
Platte County	89,322	26,797	13,398	268	$5,696,957	Very High
Buchanan County	89,201	26,760	13,380	268	$5,689,240	Very High
Christian County	77,422	23,227	11,613	232	$4,937,975	Very High
Cole County	75,990	22,797	11,399	228	$4,846,642	Very High
Cape Girardeau County	75,674	22,702	11,351	227	$4,826,488	Very High
St. Francois County	65,359	19,608	9,804	196	$4,168,597	Very High
Newton County	58,114	17,434	8,717	174	$3,706,511	Very High
Johnson County	52,595	15,779	7,889	158	$3,354,509	Very High
Lincoln County	52,566	15,770	7,885	158	$3,352,659	Very High
Pulaski County	52,274	15,682	7,841	157	$3,334,036	Very High

County	2010 Population Estimate	Potentially Affected Population	Potential Number of Persons Seeking Medical Care	Potential Number Hospitalized	Potential Charges in Dollars	Vulnerability
Taney County	51,675	15,503	7,751	155	$3,295,832	Very High
Phelps County	45,156	13,547	6,773	135	$2,880,050	Very High
Callaway County	44,332	13,300	6,650	133	$2,827,495	Very High
Camden County	44,002	13,201	6,600	132	$2,806,448	Very High
Butler County	42,794	12,838	6,419	128	$2,729,401	Very High
Pettis County	42,201	12,660	6,330	127	$2,691,580	Very High
Howell County	40,400	12,120	6,060	121	$2,576,712	Very High
Scott County	39,191	11,757	5,879	118	$2,499,602	Very High
Lawrence County	38,634	11,590	5,795	116	$2,464,077	Very High
Webster County	36,202	10,861	5,430	109	$2,308,964	Very High
Barry County	35,597	10,679	5,340	107	$2,270,377	Very High
Laclede County	35,571	10,671	5,336	107	$2,268,718	Very High
Lafayette County	33,381	10,014	5,007	100	$2,129,040	Very High
Warren County	32,513	9,754	4,877	98	$2,073,679	Very High
Stone County	32,202	9,661	4,830	97	$2,053,844	Very High
Dunklin County	31,953	9,586	4,793	96	$2,037,962	Very High
Polk County	31,137	9,341	4,671	93	$1,985,918	Very High
Stoddard County	29,968	8,990	4,495	90	$1,911,359	Very High
Marion County	28,781	8,634	4,317	86	$1,835,652	Very High
Texas County	26,008	7,802	3,901	78	$1,658,790	Very High
Adair County	25,607	7,682	3,841	77	$1,633,214	Very High
Audrain County	25,529	7,659	3,829	77	$1,628,240	Very High

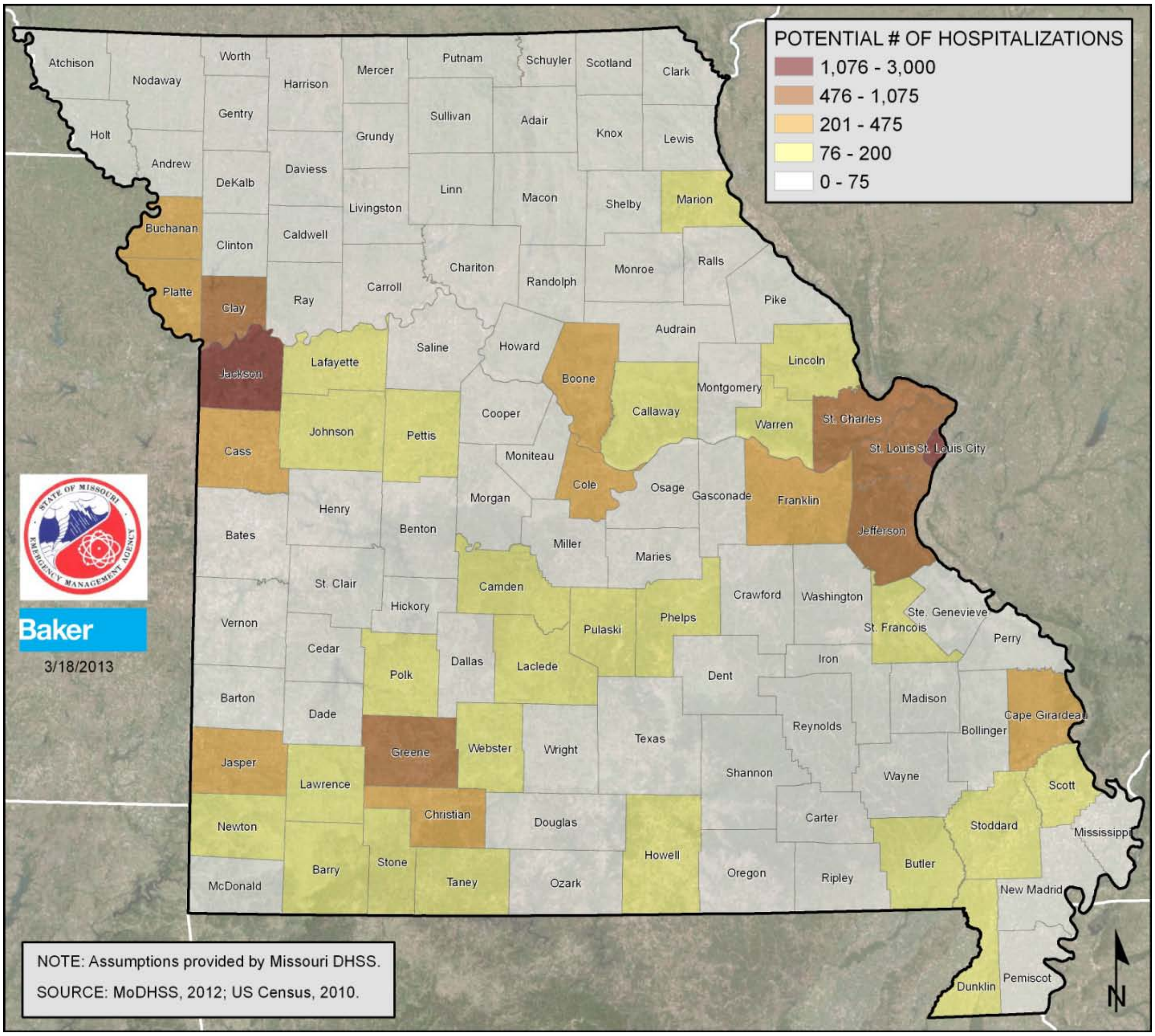
County	2010 Population Estimate	Potentially Affected Population	Potential Number of Persons Seeking Medical Care	Potential Number Hospitalized	Potential Charges in Dollars	Vulnerability
Randolph County	25,414	7,624	3,812	76	$1,620,905	Very High
Washington County	25,195	7,559	3,779	76	$1,606,937	Very High
Miller County	24,748	7,424	3,712	74	$1,578,427	Very High
Crawford County	24,696	7,409	3,704	74	$1,575,111	Very High
Ray County	23,494	7,048	3,524	70	$1,498,447	Very High
Nodaway County	23,370	7,011	3,506	70	$1,490,539	Very High
Saline County	23,370	7,011	3,506	70	$1,490,539	Very High
McDonald County	23,083	6,925	3,462	69	$1,472,234	Very High
Henry County	22,272	6,682	3,341	67	$1,420,508	Very High
Vernon County	21,159	6,348	3,174	63	$1,349,521	Very High
Clinton County	20,743	6,223	3,111	62	$1,322,989	Very High
Morgan County	20,565	6,170	3,085	62	$1,311,636	Very High
Benton County	19,056	5,717	2,858	57	$1,215,392	Very High
Perry County	18,971	5,691	2,846	57	$1,209,970	Very High
New Madrid County	18,956	5,687	2,843	57	$1,209,014	Very High
Wright County	18,815	5,645	2,822	56	$1,200,021	Very High
Pike County	18,516	5,555	2,777	56	$1,180,950	Very High
Pemiscot County	18,296	5,489	2,744	55	$1,166,919	Very High
Ste. Genevieve County	18,145	5,444	2,722	54	$1,157,288	Very High
Cooper County	17,601	5,280	2,640	53	$1,122,592	Very High
Andrew County	17,291	5,187	2,594	52	$1,102,820	Very High
Bates County	17,049	5,115	2,557	51	$1,087,385	Very High

County	2010 Population Estimate	Potentially Affected Population	Potential Number of Persons Seeking Medical Care	Potential Number Hospitalized	Potential Charges in Dollars	Vulnerability
Dallas County	16,777	5,033	2,517	50	$1,070,037	Very High
Dent County	15,657	4,697	2,349	47	$998,603	High
Moniteau County	15,607	4,682	2,341	47	$995,414	High
Macon County	15,566	4,670	2,335	47	$992,799	High
Gasconade County	15,222	4,567	2,283	46	$970,859	High
Livingston County	15,195	4,559	2,279	46	$969,137	High
Mississippi County	14,358	4,307	2,154	43	$915,753	High
Ripley County	14,100	4,230	2,115	42	$899,298	High
Cedar County	13,982	4,195	2,097	42	$891,772	High
Osage County	13,878	4,163	2,082	42	$885,139	High
Douglas County	13,684	4,105	2,053	41	$872,766	High
Wayne County	13,521	4,056	2,028	41	$862,369	High
DeKalb County	12,892	3,868	1,934	39	$822,252	High
Linn County	12,761	3,828	1,914	38	$813,897	High
Barton County	12,402	3,721	1,860	37	$791,000	High
Bollinger County	12,363	3,709	1,854	37	$788,512	High
Montgomery County	12,236	3,671	1,835	37	$780,412	High
Madison County	12,226	3,668	1,834	37	$779,774	High
Oregon County	10,881	3,264	1,632	33	$693,990	Medium
Iron County	10,630	3,189	1,595	32	$677,981	Medium
Grundy County	10,261	3,078	1,539	31	$654,447	Medium
Lewis County	10,211	3,063	1,532	31	$651,258	Medium

County	2010 Population Estimate	Potentially Affected Population	Potential Number of Persons Seeking Medical Care	Potential Number Hospitalized	Potential Charges in Dollars	Vulnerability
Ralls County	10,167	3,050	1,525	31	$648,451	Medium
Howard County	10,144	3,043	1,522	30	$646,984	Medium
St. Clair County	9,805	2,942	1,471	29	$625,363	Medium
Ozark County	9,723	2,917	1,458	29	$620,133	Medium
Hickory County	9,627	2,888	1,444	29	$614,010	Medium
Caldwell County	9,424	2,827	1,414	28	$601,063	Medium
Carroll County	9,295	2,789	1,394	28	$592,835	Medium
Maries County	9,176	2,753	1,376	28	$585,245	Medium
Harrison County	8,957	2,687	1,344	27	$571,277	Medium
Monroe County	8,840	2,652	1,326	27	$563,815	Medium
Shannon County	8,441	2,532	1,266	25	$538,367	Medium
Daviess County	8,433	2,530	1,265	25	$537,857	Medium
Dade County	7,883	2,365	1,182	24	$502,778	Medium
Chariton County	7,831	2,349	1,175	23	$499,461	Low
Clark County	7,139	2,142	1,071	21	$455,325	Low
Gentry County	6,738	2,021	1,011	20	$429,750	Low
Sullivan County	6,714	2,014	1,007	20	$428,219	Low
Reynolds County	6,696	2,009	1,004	20	$427,071	Low
Shelby County	6,373	1,912	956	19	$406,470	Low
Carter County	6,265	1,880	940	19	$399,582	Low
Atchison County	5,685	1,706	853	17	$362,589	Low
Putnam County	4,979	1,494	747	15	$317,561	Low

County	2010 Population Estimate	Potentially Affected Population	Potential Number of Persons Seeking Medical Care	Potential Number Hospitalized	Potential Charges in Dollars	Vulnerability
Holt County	4,912	1,474	737	15	$313,287	Low
Scotland County	4,843	1,453	726	15	$308,887	Low
Schuyler County	4,431	1,329	665	13	$282,609	Low
Knox County	4,131	1,239	620	12	$263,475	Low
Mercer County	3,785	1,136	568	11	$241,407	Very Low
Worth County	2,171	651	326	7	$138,466	Very Low

Figure 3.5.18.1 - Potential Vulnerability of Missouri Counties to Pandemic Influenza



Environmental Issues

According to the Missouri Department of Natural Resources 2012 Missouri Water Quality Report, "The economic costs of wastewater treatment and nonpoint source management are extremely diffuse and difficult to calculate. The total operating costs of municipal, private, and industrial treatment plants are not readily available. Likewise, it is difficult to estimate total expenditures on nonpoint source management. The amounts that the State of Missouri spends on various aspects of water pollution control and prevention, however, may give some indication of the relative investments required. The Missouri Department of Natural Resources annually spends about $2.8 million on monitoring and analysis of ambient water and related media. Approximately $3.7 million is spent on permit issuance annually and about $8.6 million on other facets of water pollution control and administrative support. Another significant expense is grants aimed at the improvement of water quality. The department awards an average of $4 million annually for projects to address nonpoint source pollution through the

federal Section 319 grant funds and about $200,000 for water quality planning projects. The department's Soil and Water Conservation Program distributes more than $24 million each year directly to landowners to address agricultural nonpoint source pollution through the reduction of sediment and to conserve and protect the quality of water resources on agricultural land. The economic benefits of improved water quality are even harder to quantify. Of all the money spent on water-based recreation and fishing in Missouri, it is nearly impossible to tell how much is dependent upon improved water quality. The same is true for the expense of drinking water treatment. But however great the economic benefits may be, the true benefits of clean water are high-quality recreation experiences, healthy and confident use of water resources and a robust aquatic biological community." Changes in Development for Jurisdictions in Hazard Prone Areas.

Public Health Emergencies

As populations increase and the cost of health care climbs, potential losses can be expected to rise.

Environmental Issues

Throughout the State, continuing suburban development impacts streams in several ways. Shortening and culverting of channels leads to the direct loss of streams and riparian areas. The increase in impervious surface area in the surrounding watershed leads to unnatural hydrograph patterns, with lower baseflow and higher stormflow. The altered channel and higher peak flows can increase erosion, while the runoff from the impervious surface carries increased levels of sediment and various chemicals from the urban environment. Elevated nutrient levels or bacterial contamination is also likely if individual or community domestic sewage systems are not well maintained.

3.5.19 Special Events

For hazard profile information for special events, see Section 3.3.19.

Overview and Analysis of Vulnerability to Special Events

Significant special events where large groups of people are gathered and expanded security and other resources are required above and beyond the resources typically available to local or state government are potential targets for attacks such as terrorist attacks and civil disorder. Regardless of the purpose for the event, special events will place a large number of people in one area at one time. Anytime people are crowded together in one place, an incident resulting from nearly any of the hazards detailed in this Risk Assessment could have compounded and devastating impacts.

It is not possible to calculate a specific vulnerability for each county in Missouri. However, because of the desire for publicity following terrorist-type attacks at special event venues, it is more likely that counties with greater population densities would be the target of such attacks. Sparsely populated rural counties are less desirable targets for publicity-seeking terrorists. It is expected that the likelihood of attack is directly related to population density or more likely to an event that is occurring or to a specific location of importance to the attacker. For example, a large venue event, such as a sporting event attended by tens of thousands of people might be considered a desirable target. Most large public venues occur in densely populated areas since those areas are able to provide the infrastructure support (hotels, eateries, etc.) for large numbers of people. A description of population density is contained in this plan in Section 3.4.

Overview and Analysis of Potential Loss Estimates to Special Events

Potential losses for this hazard include all infrastructure, critical facilities, humans and animals. The degree of impact would be directly related to the type of incident. Potential losses would include cost of repair or replacement of damaged facilities, lost economic opportunities for businesses, loss of human life, and injuries to persons. Secondary effects of infrastructure failure could include public safety hazards, spread of disease, increased morbidity and mortality among the local and distant populations and public panic.

As discussed previously, it is difficult to describe vulnerability in terms of the jurisdictions, since the nature of special events varies widely. A well-attended one time event could be subject to as much loss as a less well attended annual event. For the purposes of this plan, this loss estimate will take into account a hypothetical scenario in order to calculate potential dollar losses. Please note that this hypothetical scenario is included to provide one methodology for local jurisdictions to estimate potential losses. The hypothetical scenario is an IED attack. Analysis of vulnerable populations is aided by a program developed by Johns Hopkins University in 2006 called Electronic Mass Casualty Assessment and Planning Scenarios (EMCAPS)[qqq] which utilizes scenarios put together by the Department of Homeland Security.

****THE FOLLOWING HYPOTHETICAL SCENARIO IS FOR INSTRUCTIONAL AND ILLUSTRATIVE PURPOSES ONLY****

[qqq] Johns Hopkins University, Electronic Mass Casualty Assessment and Planning Scenarios (EMCAPS) program for predicting casualties. 2006

Scenario Overview: An Improvised Explosive Device (IED) utilizing an ammonium nitrate/fuel oil (ANFO) mixture is carried in a panel van to a parking area during a time when stadium patrons are leaving their cars to enter the stadium and it is detonated. Potential losses with this type of scenario include both human and structural assets.

Assumptions: (1) The population density in the parking lot during the beginning and ending of the games is high, at least 1 person/50 square feet. (2) The quantity of ANFO used is 4,000 lbs, similar to that used by Timothy McVeigh in the Oklahoma City bombing. (3) The Lethal Air Blast Range for such a vehicle is 200 feet according to the Bureau of Alcohol, Tobacco, Firearms and Explosives (BATF) Standards. (4) The Falling Glass Hazard distance is 2,750 feet according to BATF Explosive Standards.

Described Losses:

Total Dead	695 persons
Total Traumatic Injuries	1,218 persons
Total Urgent Care Injuries	5,967 persons
Injuries not Requiring Hospitalization	2,233 persons
Structures and Other Physical Assets (Damages would certainly occur to vehicles and depending on the proximity of other structures, damages would occur to the stadium complex itself. The exact amount of these damages is difficult to predict because of the large numbers of factors, including the type of structures nearby and the amount of insurance held by vehicle owners.)	Vehicles – Replacement cost for approximately 100 vehicles @ $15,000 per vehicle inside the 200 ft BATF described Lethal Air Blast range = $ 150,000 Repair / repainting cost for approximately 500 vehicles @ $ 4,000 per vehicle inside the BATF described Falling Glass Hazard = $2,000,000

Changes in Development for Jurisdictions in Hazard Prone Areas

As Missouri plays host to more national events and large scale venues the potential for losses increases. Proper planning for large scale events plays a significant role in mitigating future losses.

3.5.20 Terrorism

For hazard profile information for terrorism, see Section 3.3.20.

Overview and Analysis of Vulnerability to Terrorism

Terrorist acts have the potential to undermine the confidence that people have in their own security with the intent to build doubt in their government's ability to protect them from harm. Because bombs can be made so easily, the threat of a bomb should not be taken lightly. The threat of a bomb can disrupt a community almost as effectively as an actual bomb, while creating far fewer risks for the persons making the threat. Therefore, no matter how large or small the incident, a terrorist act can have a major impact on a community.

A strategic biological, or chemical attack on the United States could have the most devastating and far-reaching consequences. The potential for traditional attacks, using conventional weapons, is a scenario that is more likely to occur, based on currently available information, however even attacks of that variety are rare. Attackers are likely to have either very specific targets, such as Women's clinics, or desire wide spread publicity from the attacks and will target populous gathering, such as sporting events or rallies.

Overview and Analysis of Potential Loss Estimates to Terrorism

It is not possible to calculate a specific vulnerability for each county in Missouri. However, because of the desire for publicity following attacks, it is likely that counties with greater population densities would be the target of the majority of potential attacks. Sparsely populated rural counties are less popular targets for publicity-seeking terrorists. It is assumed that the likelihood of attack can be directly related to population density and even more likely if an event that is occurring or to a specific location of importance can be attributed to potential attackers. For example, a large venue event, such as a sporting event attended by tens of thousands of people might be considered a desirable target. Most large public venues occur in densely populated areas since those areas are able to provide the infrastructure support (hotels, eateries, etc.) for large numbers of people. A description of population density is contained in this plan in Section 3.4

Potential losses for this hazard include all infrastructure, critical facilities, humans and animals. The degree of impact would be directly related to the type of terrorist incident. Potential losses include cost of repair or replacement of damaged facilities, lost economic opportunities for businesses, loss of human life, and injuries to persons. Secondary effects of infrastructure failure could include public safety hazards, spread of disease, increased morbidity and mortality among the local and distant populations and public panic. Terrorist events are infrequent occurrences and specific amounts of estimated losses for previous occurrence are not available due to the complexity and number of variables associated with these types of hazards.

As discussed previously, it is difficult to describe vulnerability in terms of the jurisdictions most threatened by terrorist attack events due to the many variables and human element that come in to play. Therefore, for the purposes of this plan, the loss estimates will take into account a hypothetical scenario. Please note that this hypothetical scenario is included to provide one methodology for local jurisdictions to estimate potential losses. The hypothetical scenario is a chemical attack. The

hypothetical venue is a stadium situated on less than one square mile and has a seating capacity of over 45,000 persons. Surface area and parking structures are located adjacent to the stadium.

Analysis of vulnerable populations is aided by a program developed by Johns Hopkins University in 2006 called Electronic Mass Casualty Assessment and Planning Scenarios (EMCAPS) which utilizes scenarios put together by the Department of Homeland Security.

****THE FOLLOWING HYPOTHETICAL SCENARIOS ARE FOR INSTRUCTIONAL AND ILLUSTRATIVE PURPOSES ONLY****

Chemical Attack – Mustard Gas

Scenario Overview: Mustard gas is released from a light aircraft onto a stadium during a sporting event. The agent directly contaminates the stadium and the immediate surrounding area. This particular type of attack would cause harm to humans and could render portions of the stadium unusable for a short time period in order to allow for a costly clean-up. There might also be a fear by the public of long-term contamination of the stadium and subsequent boycott of games resulting in a loss of revenue and tourism dollars.

Assumptions: (1) The population density at the stadium on game day is high – approximately 75 percent of the seats, 31,000, are filled. (2) Sulphur mustards are extremely toxic and may damage eyes, skin and respiratory tract. Death sometimes results from secondary respiratory infections. (3) The rate of "worried well" is equal to 9 times the number of infected cases.

Described Losses:

Severe Eye Injuries (1-2 hours)	23,250 persons
Severe Airway Injuries (1-2 hours)	23,250 persons
Severe Skin Injuries (2 hrs to days)	27,900 persons
Total "Worried Well" Cases (9 times the number of affected cases)	251,000 persons
Deaths	620 persons

Notes: Victims will require decontamination and both long and short term treatment. Services may need to be suspended at the area until all investigations are conducted.

Changes in Development for Jurisdictions in Hazard Prone Areas

As more and more large public events are held in Missouri, and the population increases, more potential exists for these venues to become targets of attack.

3.5.21 Utilities (Interruptions and System Failures)

For hazard profile information for utility interruptions and system failures, see Section 3.3.21.

Overview and Analysis of Vulnerability to Utility Interruption and System Failure

Utilities and infrastructure are vulnerable to damage from many natural hazards. Public health and safety and potential impacts on the economy are primary concerns with this hazard. Power and telephone lines are the most vulnerable infrastructure asset; but water supply, wastewater facilities and communications towers are also vulnerable. Typically the events that cause the most damages are flood, lightning, winter storm, tornado, and wind storm. The electrical grid is vulnerable in periods of extreme heat when air conditioning use peaks. Underground utilities can also be damaged by expansive soils, erosion, earthquake and intentional or unintentional human actions. The Missouri Underground Facility Safety and Damage Prevention Act helps prevent accidental damage of underground facilities. This statute makes it illegal to excavate without first giving notice and obtaining information concerning the possible locations of underground facilities.

Utility companies are generally well prepared to deal with day-to-day outages. The earthquake threat to statewide and multi-state utilities is the greatest concern to the integrity and operability of Missouri's utilities. Severe weather causes more frequent local, and occasionally widespread, utility outages. Manmade incidents, accidental or intentional, could significantly impact utility service. Geomagnetic storms could disrupt communications and affect utility service. Planning, regulation, mitigation, and mutual aid are all just a few tools available to reduce, speed recovery from, and prevent utility interruptions and failures.

Overview and Analysis of Potential Loss Estimates to Utility Interruption and System Failure

By definition, this hazard includes all infrastructure and critical facilities that could be impacted by one or more hazard events. Electrical blackouts and power surges can damage high tech equipment but generally do not cause structural damage. Descriptions of utility/infrastructure assets that could be impacted are in Section 3.3.21 under the profile for this hazard.

Potential losses would include cost of repair or replacement of damaged facilities, lost economic opportunities for businesses. Secondary effects of infrastructure failure could include burst water pipes in homes without electricity during winter storms and damage to equipment due to power surges in the electrical grid during blackouts. Public safety hazards include risk of electrocution from downed power lines and hazard events that affect the normal functioning of wastewater facilities. Specific amounts of estimated losses are not available due to the complexity and multiple variables associated with this hazard. Loss of use estimates contained in this plan were calculated using FEMA's publication *What is a Benefit?: Guidance on Benefit-Cost Analysis of Hazard Mitigation Project, June 2009*. These figures are used to provide estimated costs associated with the loss of utilities. Table 3.5.21a provides these estimates in relation to the populations served in Missouri by county. The loss of use for each utility is provided in the heading as the loss of use cost per person per day of loss. The estimated loss of use provided for each county in Missouri represents the loss of service of the indicated utility for one day for 10 percent of the population. It is understood that in rural areas, the typical loss of use may be for a larger percentage of the population for a longer time during weather extremes. These figures do not take into account physical damages to utility equipment and infrastructure. This loss estimation

methodology does not take in to account the portion of population that does not utilize public utilities such as rural areas that use well water and home-site septic systems.

Table 3.5.21a Potential Vulnerability of Missouri Counties for Utility Failure

County	2010 Population	Potentially Affected Population	Electric ($126)	Drinking Water ($93)	Wastewater Treatment (complete loss) ($41)	Totals
Adair	25,607	2,561	$322,648	$238,145	$104,989	$665,782
Andrew	17,291	1,729	$217,867	$160,806	$70,893	$449,566
Atchison	5,685	569	$71,631	$52,871	$23,309	$147,810
Audrain	25,529	2,553	$321,665	$237,420	$104,669	$663,754
Barry	35,597	3,560	$448,522	$331,052	$145,948	$925,522
Barton	12,402	1,240	$156,265	$115,339	$50,848	$322,452
Bates	17,049	1,705	$214,817	$158,556	$69,901	$443,274
Benton	19,056	1,906	$240,106	$177,221	$78,130	$495,456
Bollinger	12,363	1,236	$155,774	$114,976	$50,688	$321,438
Boone	162,642	16,264	$2,049,289	$1,512,571	$666,832	$4,228,692
Buchanan	89,201	8,920	$1,123,933	$829,569	$365,724	$2,319,226
Butler	42,794	4,279	$539,204	$397,984	$175,455	$1,112,644
Caldwell	9,424	942	$118,742	$87,643	$38,638	$245,024
Callaway	44,332	4,433	$558,583	$412,288	$181,761	$1,152,632
Camden	44,002	4,400	$554,425	$409,219	$180,408	$1,144,052
Cape Girardeau	75,674	7,567	$953,492	$703,768	$310,263	$1,967,524
Carroll	9,295	930	$117,117	$86,444	$38,110	$241,670
Carter	6,265	627	$78,939	$58,265	$25,687	$162,890

County	2010 Population	Potentially Affected Population	Electric ($126)	Drinking Water ($93)	Wastewater Treatment (complete loss) ($41)	Totals
Cass	99,478	9,948	$1,253,423	$925,145	$407,860	$2,586,428
Cedar	13,982	1,398	$176,173	$130,033	$57,326	$363,532
Chariton	7,831	783	$98,671	$72,828	$32,107	$203,606
Christian	77,422	7,742	$975,517	$720,025	$317,430	$2,012,972
Clark	7,139	714	$89,951	$66,393	$29,270	$185,614
Clay	221,939	22,194	$2,796,431	$2,064,033	$909,950	$5,770,414
Clinton	20,743	2,074	$261,362	$192,910	$85,046	$539,318
Cole	75,990	7,599	$957,474	$706,707	$311,559	$1,975,740
Cooper	17,601	1,760	$221,773	$163,689	$72,164	$457,626
Crawford	24,696	2,470	$311,170	$229,673	$101,254	$642,096
Dade	7,883	788	$99,326	$73,312	$32,320	$204,958
Dallas	16,777	1,678	$211,390	$156,026	$68,786	$436,202
Daviess	8,433	843	$106,256	$78,427	$34,575	$219,258
DeKalb	12,892	1,289	$162,439	$119,896	$52,857	$335,192
Dent	15,657	1,566	$197,278	$145,610	$64,194	$407,082
Douglas	13,684	1,368	$172,418	$127,261	$56,104	$355,784
Dunklin	31,953	3,195	$402,608	$297,163	$131,007	$830,778
Franklin	101,492	10,149	$1,278,799	$943,876	$416,117	$2,638,792
Gasconade	15,222	1,522	$191,797	$141,565	$62,410	$395,772
Gentry	6,738	674	$84,899	$62,663	$27,626	$175,188
Greene	275,174	27,517	$3,467,192	$2,559,118	$1,128,213	$7,154,524

County	2010 Population	Potentially Affected Population	Electric ($126)	Drinking Water ($93)	Wastewater Treatment (complete loss) ($41)	Totals
Grundy	10,261	1,026	$129,289	$95,427	$42,070	$266,786
Harrison	8,957	896	$112,858	$83,300	$36,724	$232,882
Henry	22,272	2,227	$280,627	$207,130	$91,315	$579,072
Hickory	9,627	963	$121,300	$89,531	$39,471	$250,302
Holt	4,912	491	$61,891	$45,682	$20,139	$127,712
Howard	10,144	1,014	$127,814	$94,339	$41,590	$263,744
Howell	40,400	4,040	$509,040	$375,720	$165,640	$1,050,400
Iron	10,630	1,063	$133,938	$98,859	$43,583	$276,380
Jackson	674,158	67,416	$8,494,391	$6,269,669	$2,764,048	$17,528,108
Jasper	117,404	11,740	$1,479,290	$1,091,857	$481,356	$3,052,504
Jefferson	218,733	21,873	$2,756,036	$2,034,217	$896,805	$5,687,058
Johnson	52,595	5,260	$662,697	$489,134	$215,640	$1,367,470
Knox	4,131	413	$52,051	$38,418	$16,937	$107,406
Laclede	35,571	3,557	$448,195	$330,810	$145,841	$924,846
Lafayette	33,381	3,338	$420,601	$310,443	$136,862	$867,906
Lawrence	38,634	3,863	$486,788	$359,296	$158,399	$1,004,484
Lewis	10,211	1,021	$128,659	$94,962	$41,865	$265,486
Lincoln	52,566	5,257	$662,332	$488,864	$215,521	$1,366,716
Linn	12,761	1,276	$160,789	$118,677	$52,320	$331,786
Livingston	15,195	1,520	$191,457	$141,314	$62,300	$395,070
Macon	15,566	1,557	$196,132	$144,764	$63,821	$404,716

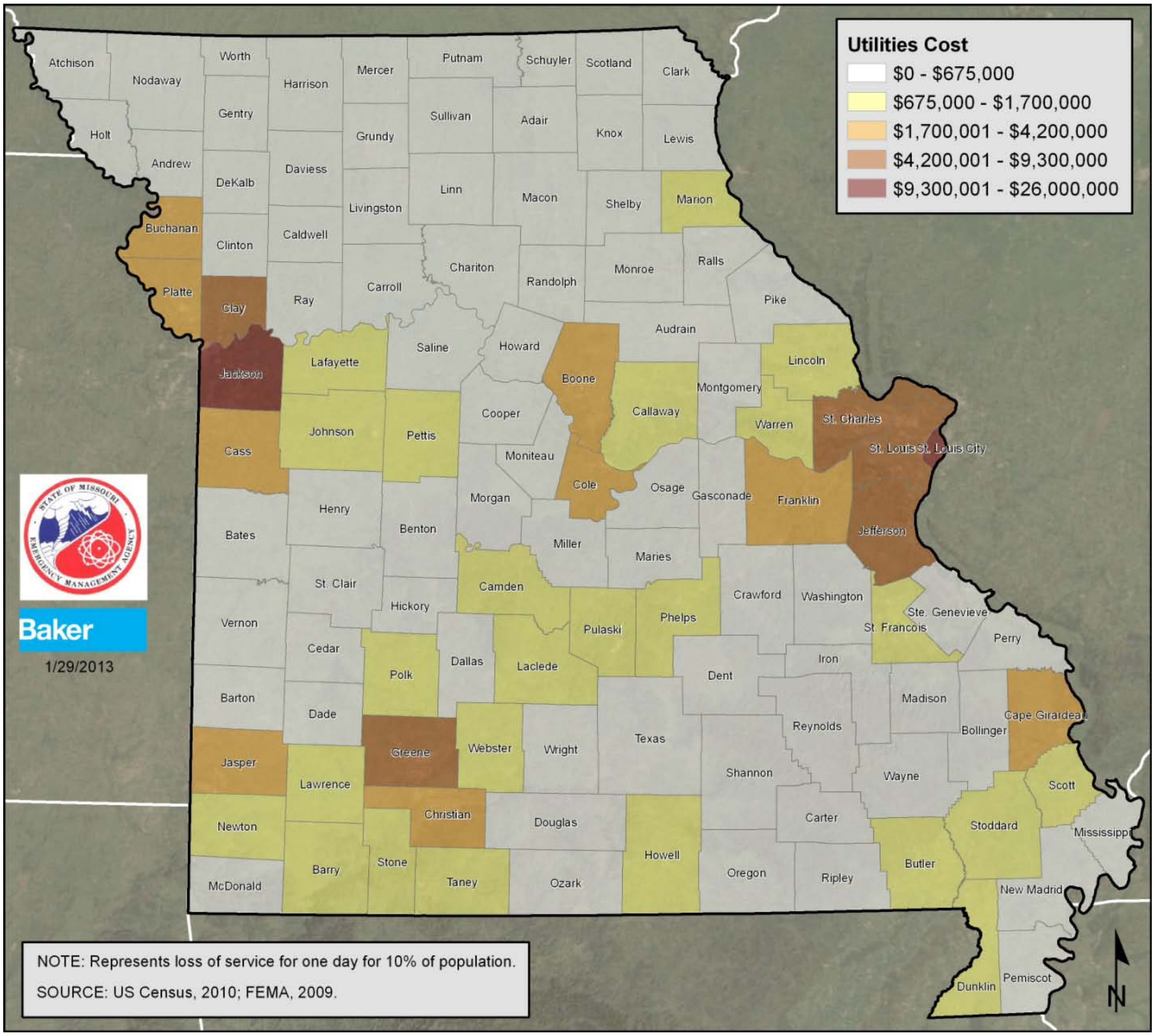
County	2010 Population	Potentially Affected Population	Electric ($126)	Drinking Water ($93)	Wastewater Treatment (complete loss) ($41)	Totals
Madison	12,226	1,223	$154,048	$113,702	$50,127	$317,876
Maries	9,176	918	$115,618	$85,337	$37,622	$238,576
Marion	28,781	2,878	$362,641	$267,663	$118,002	$748,306
McDonald	23,083	2,308	$290,846	$214,672	$94,640	$600,158
Mercer	3,785	379	$47,691	$35,201	$15,519	$98,410
Miller	24,748	2,475	$311,825	$230,156	$101,467	$643,448
Mississippi	14,358	1,436	$180,911	$133,529	$58,868	$373,308
Moniteau	15,607	1,561	$196,648	$145,145	$63,989	$405,782
Monroe	8,840	884	$111,384	$82,212	$36,244	$229,840
Montgomery	12,236	1,224	$154,174	$113,795	$50,168	$318,136
Morgan	20,565	2,057	$259,119	$191,255	$84,317	$534,690
New Madrid	18,956	1,896	$238,846	$176,291	$77,720	$492,856
Newton	58,114	5,811	$732,236	$540,460	$238,267	$1,510,964
Nodaway	23,370	2,337	$294,462	$217,341	$95,817	$607,620
Oregon	10,881	1,088	$137,101	$101,193	$44,612	$282,906
Osage	13,878	1,388	$174,863	$129,065	$56,900	$360,828
Ozark	9,723	972	$122,510	$90,424	$39,864	$252,798
Pemiscot	18,296	1,830	$230,530	$170,153	$75,014	$475,696
Perry	18,971	1,897	$239,035	$176,430	$77,781	$493,246
Pettis	42,201	4,220	$531,733	$392,469	$173,024	$1,097,226
Phelps	45,156	4,516	$568,966	$419,951	$185,140	$1,174,056

County	2010 Population	Potentially Affected Population	Electric ($126)	Drinking Water ($93)	Wastewater Treatment (complete loss) ($41)	Totals
Pike	18,516	1,852	$233,302	$172,199	$75,916	$481,416
Platte	89,322	8,932	$1,125,457	$830,695	$366,220	$2,322,372
Polk	31,137	3,114	$392,326	$289,574	$127,662	$809,562
Pulaski	52,274	5,227	$658,652	$486,148	$214,323	$1,359,124
Putnam	4,979	498	$62,735	$46,305	$20,414	$129,454
Ralls	10,167	1,017	$128,104	$94,553	$41,685	$264,342
Randolph	25,414	2,541	$320,216	$236,350	$104,197	$660,764
Ray	23,494	2,349	$296,024	$218,494	$96,325	$610,844
Reynolds	6,696	670	$84,370	$62,273	$27,454	$174,096
Ripley	14,100	1,410	$177,660	$131,130	$57,810	$366,600
Saline	23,370	2,337	$294,462	$217,341	$95,817	$607,620
Schuyler	4,431	443	$55,831	$41,208	$18,167	$115,206
Scotland	4,843	484	$61,022	$45,040	$19,856	$125,918
Scott	39,191	3,919	$493,807	$364,476	$160,683	$1,018,966
Shannon	8,441	844	$106,357	$78,501	$34,608	$219,466
Shelby	6,373	637	$80,300	$59,269	$26,129	$165,698
St. Charles	360,485	36,049	$4,542,111	$3,352,511	$1,477,989	$9,372,610
St. Clair	9,805	981	$123,543	$91,187	$40,201	$254,930
St. Francois	65,359	6,536	$823,523	$607,839	$267,972	$1,699,334
St. Louis	998,954	99,895	$12,586,820	$9,290,272	$4,095,711	$25,972,804
St. Louis City*	319,294	31,929	$4,023,104	$2,969,434	$1,309,105	$8,301,644

County	2010 Population	Potentially Affected Population	Electric ($126)	Drinking Water ($93)	Wastewater Treatment (complete loss) ($41)	Totals
Ste. Genevieve	18,145	1,815	$228,627	$168,749	$74,395	$471,770
Stoddard	29,968	2,997	$377,597	$278,702	$122,869	$779,168
Stone	32,202	3,220	$405,745	$299,479	$132,028	$837,252
Sullivan	6,714	671	$84,596	$62,440	$27,527	$174,564
Taney	51,675	5,168	$651,105	$480,578	$211,868	$1,343,550
Texas	26,008	2,601	$327,701	$241,874	$106,633	$676,208
Vernon	21,159	2,116	$266,603	$196,779	$86,752	$550,134
Warren	32,513	3,251	$409,664	$302,371	$133,303	$845,338
Washington	25,195	2,520	$317,457	$234,314	$103,300	$655,070
Wayne	13,521	1,352	$170,365	$125,745	$55,436	$351,546
Webster	36,202	3,620	$456,145	$336,679	$148,428	$941,252
Worth	2,171	217	$27,355	$20,190	$8,901	$56,446
Wright	18,815	1,882	$237,069	$174,980	$77,142	$489,190

Figure 3.5.21.1 provides the statewide map depicting estimates for loss of use of the above utilities for each county in Missouri.

Figure 3.5.21.1 - Combined Loss of Use Estimates for Electric, Drinking Water and Wastewater



Changes in Development for Jurisdictions in Hazard Prone Areas

Future development can increase vulnerability to this hazard by placing additional strains on existing infrastructure and by increasing the size and thus the exposure of infrastructure networks. In addition, utility and infrastructure development and expansion should be minimized or mitigated in known hazard areas to ensure the vulnerability to this hazard is not increased as a secondary impact to other hazard events.

3.6 Assessing Vulnerability and Estimating Losses by Jurisdiction: Integration of Local Plans

Requirements §201.4(c)(2)(ii) and §201.4(c)(2)(iii):	[The state risk assessment shall include an] overview and analysis of the state's vulnerability to the hazards described in this paragraph (c)(2), based on estimates provided in **local risk assessments** as well as the State risk assessment. The state shall describe vulnerability in terms of the jurisdictions most threatened by the identified hazards, and most vulnerable to damage and loss associated with hazard events. [The state risk assessment shall include an] overview and analysis of potential losses to identified vulnerable structures, based on estimates provided in **local risk assessments** as well as the State risk assessment.
Update §201.4(d):	Plan must be reviewed and revised to reflect changes in development.

3.6.1 Overview and Analysis of Local Plan Vulnerability Assessments

As of February 2013, 75 county-level mitigation plans (including the independent City of St. Louis) in Missouri had been approved by the Federal Emergency Management Agency. This gave the State the opportunity to review the local risk assessments to help them better understand its vulnerability in terms of the jurisdictions most threatened by hazards.

In its analysis, the State was interested in how the local governments ranked the hazards in their jurisdictions and the potential losses (i.e., people, buildings, and dollar values) associated with the hazards of greatest concern. Where available, the State extracted the "Ranking of Adverse Impact on Community" information from the "Hazard Identification and Analysis" table. This ranking factor is based on a combination of probability, severity, and extent of the hazard and was determined to be the best measure of overall risk in the plans. This ranking was either numeric or described in terms of high, medium, or low. In cases where this information was not available, rankings were determined from other factors such as risk priority and severity.

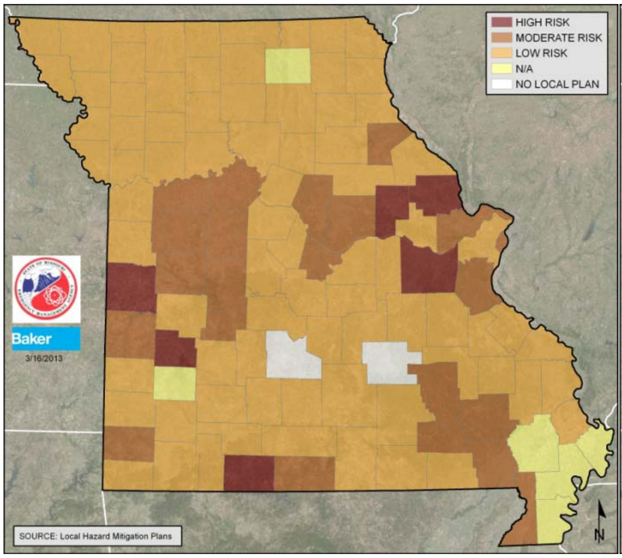
To properly analyze and summarize the data, a common scale was required. During the review of the local plan risk assessments, all rankings of adverse impact were converted to a High, Moderate, or Low scale. In most instances, the original ranking was done on a 1-5 scale, with 5 being High, 3-4 being Moderate, and 1-2 being Low. However, other scales were also employed and documented during the process. In addition to the risk summary, the number of persons, buildings, and building values at risk to high and moderate hazards were captured. All information was summarized to the county level. This analysis revealed that not all of the county-level plans included manmade hazards in their analysis, but rather focused on the natural hazards. In addition, only seven of the local plans discussed levee failure

as a hazard separate from flood. To determine areas of the state that are potentially impacted by these hazards, see Sections 3.3.3 and 3.5.3 of the State Profile and Vulnerability Analysis for Levee failure as well as the State Profile and Vulnerability sections for the man-made hazards listed in Section 3.2.2.

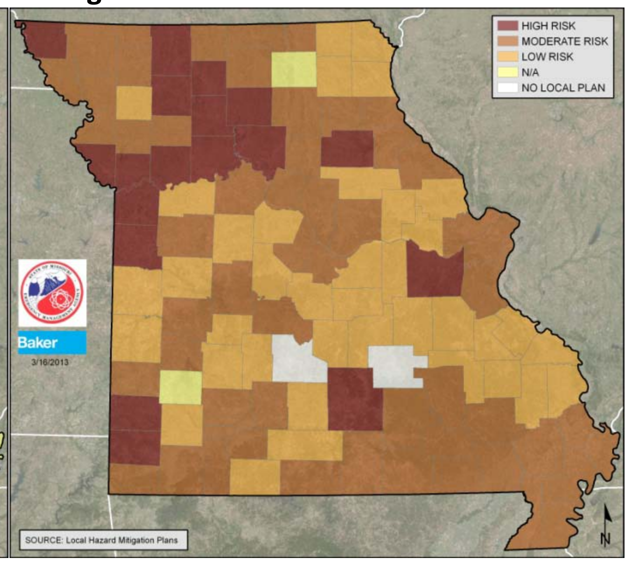
Based on the analysis of all approved local plans, Figure 3.6.1.1, Figure 3.6.1.2, and Figure 3.6.1.3 that follow indicate the hazard rankings (High, Moderate, and Low) for each county for each of the 10 natural hazards considered in local plans. For those hazards indicating N/A, that hazard was not separately profiled in the local plan. The following maps were developed for the benefit of SEMA and local planners in assisting their identification of local trends in hazards that may assist with future plan updates and outreach efforts.

Figure 3.6.1.1 - Local Plan Risk Summary for Dam Failure, Drought, Earthquake, and Fire

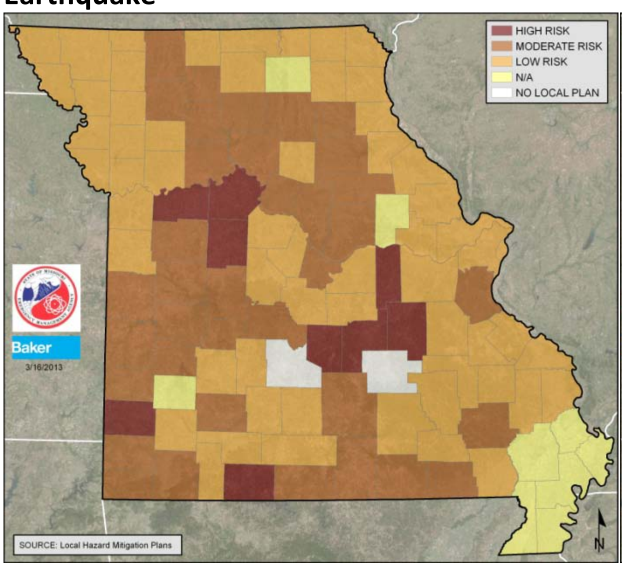
Dam Failure



Drought



Earthquake



Fire

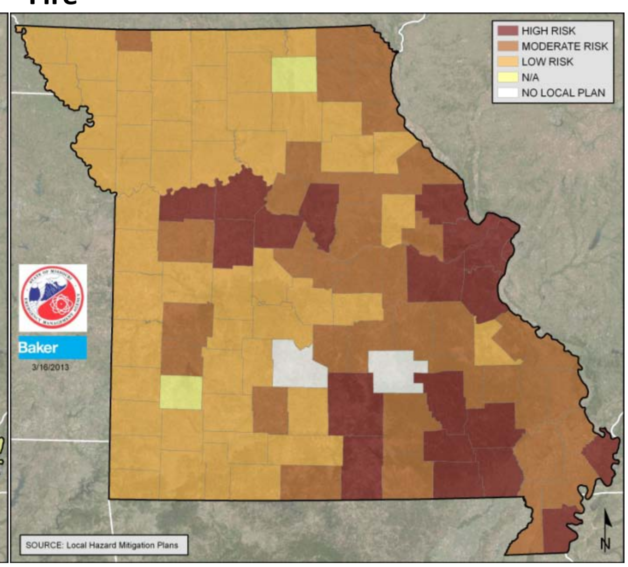
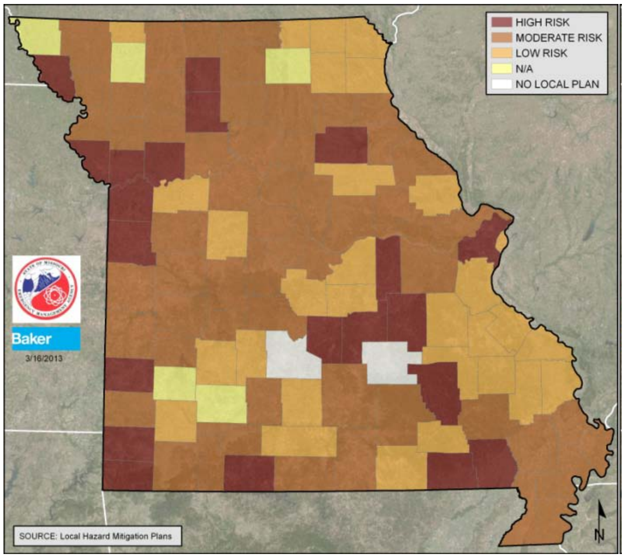
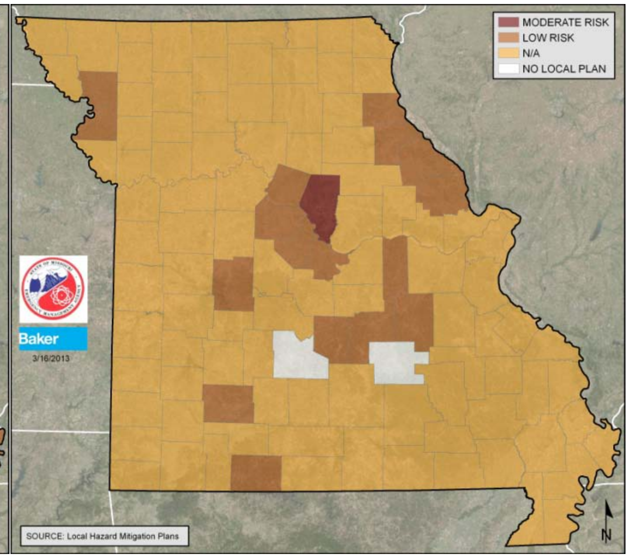


Figure 3.6.1.2 - Local Plan Risk Summary for Heat Wave, Land Subsidence/Sinkholes, Riverine Flooding, and Severe Thunderstorms

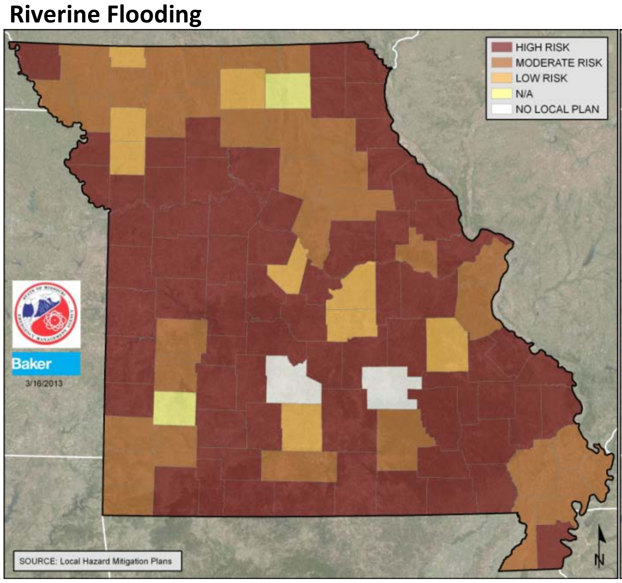
Heat Wave



Land Subsidence/Sinkholes



Riverine Flooding



Severe Thunderstorms

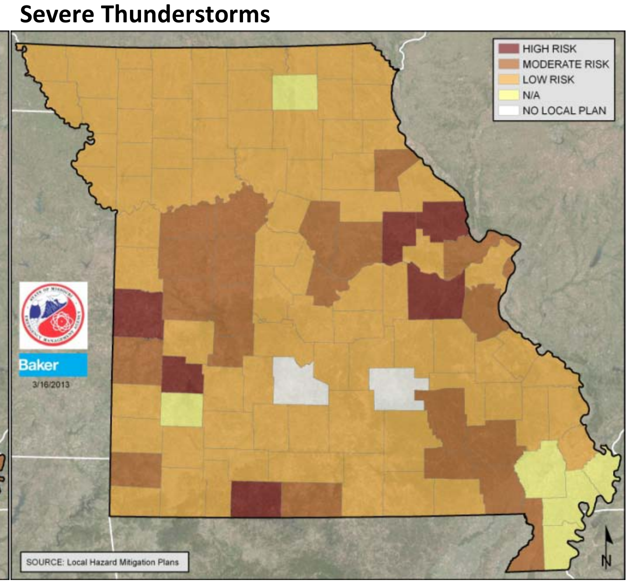
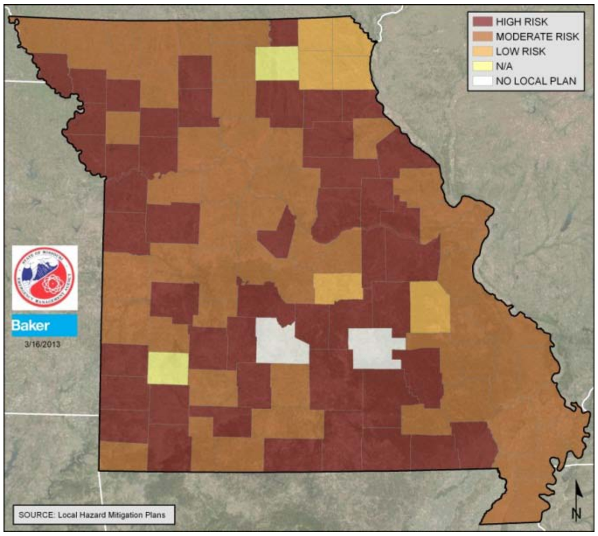
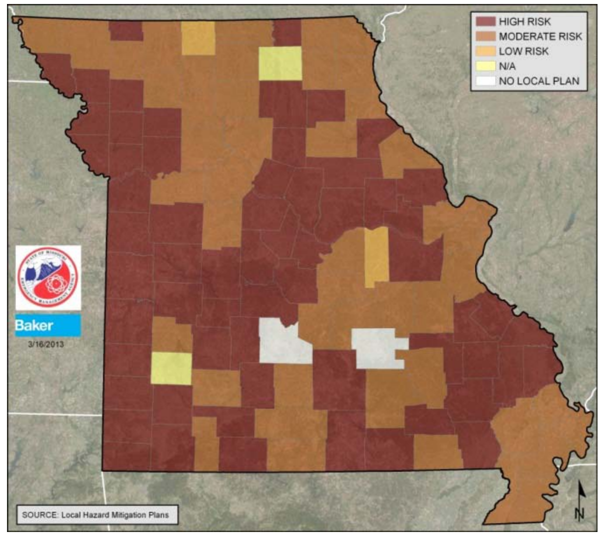


Figure 3.6.1.3 - Local Plan Risk Summary for Severe Winter Weather/Snow/Ice/Severe cold, Tornadoes, Levees

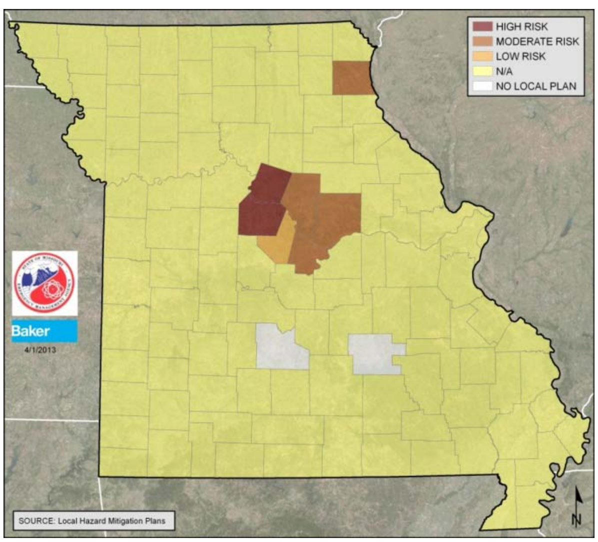
Severe Winter Weather



Tornadoes



Levee Failure



The local risk assessment summary allowed for an analysis of which hazards are of high concern to particular counties. Table 3.6.1a lists all the hazards and the number of counties that ranked them at each of the scale levels: High, Moderate, and Low. Seven of the local plans independently ranked levee failure. In addition, 22 counties ranked lightning as a separate hazard. Six Counties ranked lightning high, one ranked lightning moderate, and fifteen ranked lightning low. The data suggests that the top ranked hazards statewide in order are Riverine Flooding, Tornadoes, Severe Thunderstorms, Severe Winter Weather, Extreme Temperature, Earthquakes, Drought, Fires, Dam Failure, and Land Subsidence.

Table 3.6.1a Local Risk Assessment Hazards Ranking Summary (Ranked by Number of Highs)

Hazard	High	Moderate	Low	N/A
Riverine Flooding (Major and Flash)	68	35	9	3
Tornadoes	63	47	2	3
Severe Thunderstorms (wind, hail, lightning)	53	39	1	22
Severe Winter Weather/Snow/Ice/Severe Cold	48	58	6	3
Extreme Temperature	21	58	30	6
Earthquakes	20	38	54	3
Drought	18	56	38	3
Fires (Urban/Structural and Wild)	9	37	59	10
Dam Failure	6	23	78	7
Land Subsidence/Sinkholes	-	1	17	96

Table 3.6.1b shows the rankings each county assigned these hazards. The counties highlighted in blue did not have an approved plan at the time this report was developed and these counties were not included for the hazard rankings. The county names highlighted in yellow denote counties that had either new or updated plans since the 2010 State Mitigation Plan update. This plan uses all available information and since newer data was not available for this plan update the older information was leverage them.

Table 3.6.1b Hazard Rankings by County

County	Dam Failure	Drought	Earthquake	Fires (structural, urban and wild)	Heat Wave	Landslide/Land Subsidence	Riverine Flooding (Major and Flash)	Severe Winter Weather	Thunderstorms	Tornadoes	Lightning
Adair	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Andrew	low	mod	low	low	mod	low	mod	high	high	high	N/A
Atchison	low	high	low	low	N/A	N/A	high	mod	mod	mod	N/A
Audrain	low	low	mod	mod	low	N/A	mod	high	N/A	high	N/A
Barry	low	mod	low	mod	mod	N/A	high	high	mod	high	N/A
Barton	low	mod	low	mod	high	N/A	high	high	high	high	N/A
Bates	high	low	low	mod	mod	N/A	high	mod	high	high	N/A
Benton	mod	mod	low	mod	mod	low	high	mod	high	high	N/A
Bollinger	low	low	mod	low	low	N/A	high	mod	high	high	N/A
Boone	mod	mod	high	mod	mod	mod	mod	mod	high	high	N/A
Buchanan	low	mod	low	low	mod	low	high	high	high	high	N/A
Butler	mod	mod	high	low	high	N/A	high	high	N/A	high	N/A
Caldwell	low	mod	low	low	mod	N/A	high	high	N/A	high	N/A
Callaway	mod	mod	mod	mod	mod	N/A	high	high	mod	high	N/A
Camden	low	mod	low	mod	mod	N/A	high	high	N/A	high	N/A
Cape Girardeau	low	low	mod	low	low	N/A	high	mod	high	high	high

County	Dam Failure	Drought	Earthquake	Fires (structural, urban and wild)	Heat Wave	Landslide/Land Subsidence	Riverine Flooding (Major and Flash)	Severe Winter Weather	Thunderstorms	Tornadoes	Lightning
Carroll	low	high	low	mod	mod	N/A	high	mod	high	mod	low
Carter	mod	mod	high	low	low	N/A	high	mod	N/A	high	N/A
Cass	low	high	low	low	high	N/A	high	high	N/A	high	N/A
Cedar	high	mod	mod	mod	mod	N/A	mod	mod	high	mod	N/A
Chariton	low	high	low	mod	mod	N/A	high	mod	mod	mod	low
Christian	low	mod	low	low	mod	N/A	high	high	high	high	N/A
Clark	low	low	mod	low	low	N/A	high	low	mod	mod	N/A
Clay	low	high	low	low	high	N/A	high	high	N/A	high	N/A
Clinton	low	mod	low	low	mod	N/A	low	mod	high	high	N/A
Cole	mod	mod	mod	mod	mod	low	high	mod	high	high	N/A
Cooper	low	low	high	low	mod	low	high	mod	high	high	N/A
Crawford	low	low	mod	high	high	low	high	high	mod	mod	N/A
Dade	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Dallas	low	low	low	low	low	N/A	high	high	high	high	N/A
Daviess	low	high	low	mod	mod	N/A	mod	mod	mod	mod	low
DeKalb	low	low	low	low	mod	N/A	low	high	high	high	N/A
Dent	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

County	Dam Failure	Drought	Earthquake	Fires (structural, urban and wild)	Heat Wave	Landslide/Land Subsidence	Riverine Flooding (Major and Flash)	Severe Winter Weather	Thunderstorms	Tornadoes	Lightning
Douglas	low	low	low	low	low	N/A	mod	mod	mod	mod	N/A
Dunklin	mod	mod	mod	N/A	mod	N/A	mod	mod	high	mod	low
Franklin	high	high	high	low	mod	N/A	high	high	N/A	high	N/A
Gasconade	low	low	mod	high	high	low	high	high	high	low	N/A
Gentry	low	mod	low	low	N/A	N/A	mod	mod	mod	mod	N/A
Greene	low	mod	low	mod	N/A	low	high	mod	mod	mod	N/A
Grundy	low	high	low	mod	high	N/A	mod	high	mod	mod	low
Harrison	low	high	low	mod	mod	N/A	mod	mod	mod	mod	low
Henry	mod	low	low	mod	mod	N/A	high	mod	high	high	N/A
Hickory	mod	low	low	mod	mod	N/A	high	mod	high	high	N/A
Holt	low	mod	low	low	high	N/A	mod	high	high	high	N/A
Howard	low	mod	mod	mod	mod	low	high	mod	high	high	N/A
Howell	low	mod	high	mod	mod	N/A	high	high	high	high	high
Iron	low	low	mod	low	low	N/A	high	mod	high	high	N/A
Jackson	low	high	low	low	high	N/A	high	high	N/A	high	N/A
Jasper	low	high	low	high	mod	N/A	mod	high	high	high	N/A
Jefferson	mod	mod	high	mod	low	N/A	mod	mod	N/A	mod	N/A

County	Dam Failure	Drought	Earthquake	Fires (structural, urban and wild)	Heat Wave	Landslide/Land Subsidence	Riverine Flooding (Major and Flash)	Severe Winter Weather	Thunderstorms	Tornadoes	Lightning
Johnson	mod	mod	mod	mod	mod	N/A	high	high	high	high	N/A
Knox	low	low	mod	low	low	N/A	high	low	mod	mod	N/A
Laclede	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Lafayette	mod	low	high	high	low	N/A	high	mod	mod	mod	N/A
Lawrence	low	low	low	low	low	N/A	mod	high	high	high	N/A
Lewis	low	low	mod	low	low	N/A	high	low	mod	mod	mod
Lincoln	high	low	high	low	low	low	high	mod	high	high	N/A
Linn	low	high	low	mod	mod	N/A	mod	mod	mod	mod	low
Livingston	low	high	low	mod	high	N/A	high	high	mod	mod	low
Macon	low	mod	low	mod	mod	N/A	mod	high	high	high	N/A
Madison	low	low	mod	low	low	N/A	high	mod	high	high	high
Maries	low	low	low	low	low	N/A	low	low	mod	mod	N/A
Marion	low	mod	mod	low	mod	low	high	high	mod	mod	N/A
McDonald	low	mod	low	mod	high	N/A	mod	mod	high	high	N/A
Mercer	low	mod	low	low	mod	N/A	mod	mod	mod	low	low
Miller	low	low	low	low	low	N/A	high	mod	high	high	high
Mississippi	N/A	mod	high	N/A	mod	N/A	mod	mod	high	mod	low

County	Dam Failure	Drought	Earthquake	Fires (structural, urban and wild)	Heat Wave	Landslide/Land Subsidence	Riverine Flooding (Major and Flash)	Severe Winter Weather	Thunderstorms	Tornadoes	Lightning
Moniteau	low	mod	mod	low	mod	low	low	high	high	high	N/A
Monroe	low	high	low	mod	high	N/A	mod	high	mod	mod	N/A
Montgomery	high	low	low	N/A	mod	N/A	high	high	high	high	N/A
Morgan	low	low	low	low	mod	N/A	high	mod	high	high	high
New Madrid	N/A	mod	mod	N/A	mod	N/A	mod	mod	high	mod	low
Newton	mod	high	low	mod	high	N/A	mod	high	mod	high	N/A
Nodaway	low	mod	low	low	mod	N/A	mod	mod	mod	mod	N/A
Oregon	low	mod	mod	mod	low	N/A	high	high	high	high	N/A
Osage	low	low	mod	low	low	N/A	low	mod	mod	mod	N/A
Ozark	mod	mod	mod	mod	mod	N/A	high	high	low	mod	N/A
Pemiscot	N/A	mod	high	N/A	mod	N/A	high	mod	high	mod	low
Perry	low	low	mod	low	low	N/A	high	mod	high	high	N/A
Pettis	mod	low	high	high	low	N/A	high	mod	mod	mod	N/A
Phelps	low	low	mod	high	high	low	high	high	high	mod	N/A
Pike	low	mod	mod	low	mod	low	high	high	mod	mod	N/A
Platte	low	high	low	low	high	N/A	high	high	N/A	high	N/A
Polk	low	low	low	low	low	N/A	high	high	high	high	N/A

County	Dam Failure	Drought	Earthquake	Fires (structural, urban and wild)	Heat Wave	Landslide/Land Subsidence	Riverine Flooding (Major and Flash)	Severe Winter Weather	Thunderstorms	Tornadoes	Lightning
Pulaski	low	low	mod	high	high	low	high	high	high	mod	N/A
Putnam	low	mod	low	low	mod	N/A	mod	mod	mod	mod	low
Ralls	mod	mod	low	low	mod	low	high	mod	high	high	N/A
Randolph	low	mod	mod	low	mod	N/A	mod	mod	N/A	high	N/A
Ray	low	high	low	low	high	N/A	high	high	N/A	high	N/A
Reynolds	mod	mod	high	low	high	N/A	high	high	N/A	mod	N/A
Ripley	low	mod	high	mod	high	N/A	high	high	mod	mod	N/A
Saline	mod	mod	high	high	mod	N/A	high	mod	mod	mod	N/A
Schuyler	low	mod	low	low	low	N/A	mod	high	mod	high	N/A
Scotland	low	low	mod	low	low	N/A	high	low	mod	mod	N/A
Scott	low	mod	mod	N/A	mod	N/A	mod	mod	high	mod	low
Shannon	low	mod	mod	low	mod	N/A	mod	high	mod	mod	N/A
Shelby	low	mod	low	mod	mod	N/A	mod	high	high	high	N/A
St. Charles	mod	mod	high	low	mod	N/A	high	mod	N/A	mod	N/A
St. Clair	low	mod	mod	mod	mod	N/A	mod	high	high	high	N/A
St. Francois	low	low	low	low	low	N/A	high	mod	high	high	N/A
St. Louis	mod	mod	high	low	low	N/A	mod	mod	N/A	mod	N/A

County	Dam Failure	Drought	Earthquake	Fires (structural, urban and wild)	Heat Wave	Landslide/Land Subsidence	Riverine Flooding (Major and Flash)	Severe Winter Weather	Thunderstorms	Tornadoes	Lightning
St. Louis City*	low	mod	high	low	high	N/A	mod	mod	N/A	mod	N/A
Ste. Genevieve	low	low	mod	low	low	N/A	high	mod	high	high	N/A
Stoddard	N/A	mod	mod	N/A	mod	N/A	mod	mod	mod	mod	N/A
Stone	low	mod	low	low	mod	N/A	high	mod	mod	mod	N/A
Sullivan	low	mod	low	low	mod	N/A	low	mod	mod	mod	low
Taney	high	low	low	high	high	low	high	mod	high	high	high
Texas	low	high	high	mod	mod	N/A	high	high	N/A	high	N/A
Vernon	mod	low	low	mod	mod	N/A	high	mod	high	high	N/A
Warren	low	low	mod	low	mod	N/A	mod	high	high	high	N/A
Washington	low	low	mod	low	low	N/A	low	low	mod	mod	N/A
Wayne	mod	mod	high	mod	mod	N/A	high	mod	N/A	high	N/A
Webster	low	mod	mod	low	mod	N/A	high	high	high	high	N/A
Worth	low	mod	mod	low	low	N/A	low	mod	mod	high	N/A
Wright	low	low	low	low	low	N/A	low	mod	mod	mod	N/A

Legend: The counties highlighted in blue did not have an approved plan at the time this report was developed. The county names highlighted in yellow denote counties that had either new or updated plans since the 2010 State Mitigation Plan update; N/A indicates the hazard was not separately addressed.

3.6.2 Overview and Analysis of Local Plan Potential Loss Estimates

To assess potential losses, the State extracted data from local plans' vulnerability assessments for the hazards the jurisdictions had ranked either High or Moderate. A generic statement in many of the plans reads "loss estimates were calculated using a combination of information from the community profiles, historical loss data in the hazard profiles, parcel information, and general knowledge of the jurisdiction. Rough economic estimates were also included. For assessments reflecting 100 percent of the county's total resources, the planning area should be assumed to be evenly at risk to that respective hazard." Thus, for many hazards that could have an impact anywhere in the county, such as severe winter weather or tornadoes, it was difficult to refine the loss estimate further.

After extensive review of the loss-estimate data, the State determined that it was not suitable for county to county comparisons of loss, due largely to the different methods used by the counties to estimate, or interpret, potential loss. Reasons for largely excluding this data include:

- Accurate loss ratios were not possible as total exposure was rarely identified. Many plans considered total vulnerability to be the potential losses of all hazards added together, which would mean losing property many times over.
- Hazard scenarios were not consistent and therefore not comparable against each other (e.g., one county may have considered vulnerability to an F2 tornado that has an impact on 10 percent of the jurisdiction, where another county considered an F4 tornado with an impact on 40 percent of the jurisdiction).
- There was no consistently applied definition of "undeveloped." Some counties considered it unincorporated land, others considered it potential future development, some considered it rural, and others did not specify. This added to the complexity of the data capture process.

The exceptions to the above issues were flood, earthquake, and tornado where many of the plans were able to summarize the population and buildings at risk within the potential hazard area. Table 3.6.2a, Table 3.6.2b, and Table 3.6.2c provide flood, earthquake, and tornado loss estimate summary data for each county and the City of St. Louis. Again, the counties highlighted in blue did not have an approved plan available for review and the counties highlighted in yellow had new or updated plans since the 2010 State Mitigation Plan. While there were many tornadoes, some counties populations were not impacted by the tornadoes. These are indicated with N/A.

Table 3.6.2a Local Plan Tornado Loss Estimate Summary

County	Population Impacted	Total Buildings	Buildings Impacted	Approximate Value Affected	Flood Loss Ratio (based on exposure)	Comments
Adair	N/A	11986	N/A	N/A	N/A	N/A
Andrew	1079	7791	109	$43,287,000	0.013990502	N/A
Atchison	1,384	3344	574	$7,900,000	0.171650718	N/A

County	Population Impacted	Total Buildings	Buildings Impacted	Approximate Value Affected	Flood Loss Ratio (based on exposure)	Comments
Audrain	6,787	11915	2,558	$385,000,000	0.214687369	N/A
Barry	755	18297	10	$18,100,360	0.000546538	N/A
Barton	2,508	6247	1,322	$1,739,350,031	0.211621578	N/A
Bates	4,173	8273	1,641	$35,084,313	0.198356098	0.140312
Benton	4,882	14363	2,172	$34,629,261	0.15122189	N/A
Bollinger	1,794	6060	809	$44,486,634	0.13349835	0.415789
Boone	N/A	73126	639	N/A	0.008738342	N/A
Buchanan	1,339	41140	402	$94,573,000	0.009771512	N/A
Butler	N/A	21070	19	$1,270,000	0.000901756	N/A
Caldwell	N/A	5025	56	$361,000	0.011144279	N/A
Callaway	N/A	19592	N/A	N/A	N/A	N/A
Camden	1,205	41337	1,115	$170,309,549	0.026973414	N/A
Cape Girardeau	9,077	34908	2451	$204,704,161	0.070213132	N/A
Carroll	N/A	5094	600	$6,000,000	0.11778563	N/A
Carter	13,310	3378	3,723	$36,392,800	1.102131439	0.5
Cass	19,455	41880	4,672	$919,399,055	0.111556829	0.167831
Cedar	3,004	7637	950	$32,179,302	0.124394396	0
Chariton	N/A	4547	1,038	$10,311,857	0.228282384	N/A
Christian	3,818	32572	935	$32,783,522	0.028705637	N/A
Clark	1,123	3739	356	$17,210,900	0.095212624	N/A
Clay	48,916	96960	9,499	$1,853,812,572	0.097968234	0.190713
Clinton	N/A	9581	566	$51,488,476	0.059075253	N/A
Cole	N/A	35469	N/A	N/A	N/A	N/A
Cooper	N/A	8222	N/A	N/A	N/A	N/A
Crawford	N/A	12709	N/A	N/A	N/A	N/A
Dade	N/A	4202	N/A	N/A	N/A	N/A
Dallas	1,300	7930	381	$11,229,595	0.048045397	0.207214
Daviess	N/A	4613	N/A	N/A	N/A	N/A
DeKalb	N/A	4700	N/A	$6,481,757	N/A	N/A
Dent	N/A	7678	N/A	N/A	N/A	N/A
Douglas	3,167	6667	1,000	$64,195,322	0.1499925	0.150718
Dunklin	11626	15832	3340	$80,617,405	0.210965134	N/A
Franklin	25,349	46470	7,717	$617,321,085	0.166064127	0.172615
Gasconade	N/A	8894	343	$18,595,000	0.038565325	N/A
Gentry	2,792	3560	1,070	$93,409,500	0.300561798	0.298562
Greene	116,173	130805	31770	$6,833,591,442	0.242880624	N/A

County	Population Impacted	Total Buildings	Buildings Impacted	Approximate Value Affected	Flood Loss Ratio (based on exposure)	Comments
Grundy	N/A	5567	54	$1,448,500	0.009700018	0.044372
Harrison	N/A	4904	N/A	N/A	N/A	N/A
Henry	5,126	11861	2,189	$44,779,092	0.184554422	0.342934
Hickory	4,402	6970	1,247	$38,585,065	0.178909613	0.1248
Holt	2,418	3144	984	$53,054,092	0.312977099	0.520207
Howard	N/A	5092	N/A	N/A	N/A	N/A
Howell	154	19398	284	$589,039,448	0.014640685	N/A
Iron	1,406	5568	645	$49,857,396	0.115840517	0.385017
Jackson	160,849	332094	29,184	$4,341,112,512	0.087878733	0.171425
Jasper	1,223	54293	552	$7,361,000	0.010167057	N/A
Jefferson	47,077	91200	9,237	$821,690,000	0.101282895	0.139495
Johnson	966	22848	378	$10,000,000	0.016544118	N/A
Knox	907	2478	219	$1,878,783	0.088377724	N/A
Laclede	N/A	16959	N/A	N/A	N/A	N/A
Lafayette	4,941	15990	3,536	$99,928,965	0.221138211	N/A
Lawrence	1,266	17572	344	$10,012,915	0.019576599	0.075828
Lewis	4,057	4935	410	$21,995,900	0.083080041	N/A
Lincoln	18,793	21589	5,433	$308,533,135	0.251655936	0.330431
Linn	N/A	7193	N/A	N/A	N/A	N/A
Livingston	N/A	7374	8	$125,900	0.001084893	0.005701
Macon	4,138	10317	1,475	$240,100,000	0.142967917	N/A
Madison	1,923	8434	684	$35,844,502	0.081100308	N/A
Maries	N/A	6382	N/A	N/A	N/A	N/A
Marion	4,358	4815	1,497	$257,000,000	0.310903427	N/A
McDonald	7,288	13969	2,173	$127,313,096	0.155558737	N/A
Mercer	153	2266	98	$9,921,590	0.043248014	0.104385
Miller	1,554	13585	1,087	$7,905,953	0.080014722	N/A
Mississippi	2541	6211	1401	$78,212,475	0.225567541	0.58
Moniteau	N/A	6714	N/A	N/A	N/A	N/A
Monroe	2,444	5187	970	$142,100,000	0.187005976	N/A
Montgomery	5,246	6784	1,511	$87,155,460	0.222729953	0.178898
Morgan	969	16239	302	$1,215,075	0.018597204	N/A
New Madrid	4218	9233	1327	$225,319,912	0.1437236	1.62
Newton	561	26042	370	$3,976,500	0.014207818	N/A
Nodaway	N/A	10362	464	$3,496,705	0.044779	N/A
Oregon	1,314	5711	49	$10,124,690	0.008579933	N/A

County	Population Impacted	Total Buildings	Buildings Impacted	Approximate Value Affected	Flood Loss Ratio (based on exposure)	Comments
Osage	N/A	6849	N/A	N/A	N/A	N/A
Ozark	1,505	5805	826	$19,407,725	0.142291128	N/A
Pemiscot	5243	8940	1383	$20,351,425	0.154697987	18.53
Perry	2,686	9167	887	$62,993,658	0.096760118	0.184246
Pettis	N/A	19710	15	$15,474,000	0.000761035	0.27
Phelps	N/A	20881	180	$10,103,000	0.008620277	N/A
Pike	2,827	8610	925	$157,300,000	0.107433217	N/A
Platte	20,499	40468	3,633	$923,119,789	0.089774637	0.233123
Polk	2,652	14247	658	$22,344,582	0.046185162	0.011156
Pulaski	N/A	18683	125	$1,063,000	0.006690574	N/A
Putnam	N/A	3010	N/A	$587,000	N/A	0.044136
Ralls	1,503	5529	588	$75,000,000	0.106348345	N/A
Randolph	6,474	11558	2,084	$347,800,000	0.180308012	N/A
Ray	6,332	10709	1,683	$302,482,630	0.157157531	0.259994
Reynolds	24,728	4174	7,917	$171,361,564	1.896741735	N/A
Ripley	10,148	6869	3,707	$26,107,242	0.539670986	0.321302
Saline	3,563	10935	1,530	$64,676,191	0.139917695	0.102041
Schuyler	N/A	2527	N/A	$3,792,777	N/A	N/A
Scotland	107	2525	48	$2,734,490	0.019009901	N/A
Scott	7754	18578	2634	$74,340,410	0.141780601	22
Shannon	1,101	4299	452	$24,274,786	0.10514073	0.114999
Shelby	714	3709	268	$42,800,000	0.072256673	N/A
St. Charles	188,950	144865	45,701	$7,494,640,100	0.315473027	0.077315
St. Clair	4,330	5891	1,764	$50,417,646	0.299439823	0.386116
St. Francois	7,567	29745	2,408	$156,761,066	0.080954782	0.366435
St. Louis	333,739	187725	73,470	$12,248,619,583	0.391370356	0.137381
St. Louis City*	65,658	463317	12,203	$1,149,862,000	0.026338339	0.065883
Ste. Genevieve	4,569	9175	1,127	$104,379,719	0.122833787	0.408639
Stoddard	5,666	14835	3,165	$141,769,567	0.213346815	N/A
Stone	1,531	20352	523	$11,246,890	0.02569772	N/A
Sullivan	N/A	3661	9	$25,279,000	0.002458345	N/A
Taney	N/A	29298	216	$65,510,038	0.007372517	N/A
Texas	1,341	12596	424	$30,999,698	0.03366148	N/A
Vernon	5,126	10122	2,189	$46,779,092	0.216261608	0.140067
Warren	14,042	15173	3,060	$246,855,003	0.201674026	0.179255
Washington	N/A	11285	N/A	N/A	N/A	N/A

County	Population Impacted	Total Buildings	Buildings Impacted	Approximate Value Affected	Flood Loss Ratio (based on exposure)	Comments
Wayne	34,663	8352	9,874	$110,973,597	1.182231801	N/A
Webster	2,472	15027	952	$9,568,000	0.063352632	N/A
Worth	238	1300	190	$12,200,000	0.146153846	N/A
Wright	1,975	9285	968	$48,211,560	0.104254173	N/A

Legend: The counties highlighted in blue did not have an approved plan at the time this report was developed. The county names highlighted in yellow denote counties that had either new or updated plans since the 2010 State Mitigation Plan update

Table 3.6.2b Local Plan Earthquake Loss Estimate Summary

County	Population Impacted	Total Buildings	Buildings Impacted	Approximate Value Affected	Earthquake Loss Ratio (based on exposure)	Comments
Adair	N/A	11986	N/A	N/A	N/A	N/A
Andrew	range 0-500	7791	N/A	$8,000	N/A	N/A
Atchison	3,215	3344	1,552	$162,900,000	0.464114833	N/A
Audrain	2,714	11915	897	$154,100,000	0.075283256	N/A
Barry	116	18297	0	$3,070,715	0	N/A
Barton	125	6247	71	$87,703,668	0.011365455	N/A
Bates	N/A	8273	N/A	N/A	N/A	N/A
Benton	5,369	14363	2,321	$40,851,804	0.161595767	N/A
Bollinger	N/A	6060	N/A	N/A	N/A	N/A
Boone	N/A	73126	N/A	N/A	N/A	N/A
Buchanan	range 0-500	41140	N/A	$69,000	N/A	N/A
Butler	N/A	21070	N/A	$908,027	N/A	N/A
Caldwell	N/A	5025	56	$361,000	0.011144279	N/A
Callaway	N/A	19592	N/A	N/A	N/A	N/A
Camden	1,853	41337	1,667	$247,119,261	0.040327068	N/A
Cape Girardeau	6,274	34908	1615	$141,000,048	0.046264467	N/A
Carroll	N/A	5094	N/A	N/A	N/A	N/A
Carter	N/A	3378	N/A	N/A	0	N/A
Cass	3,891	41880	934	$183,879,811	0.022301815	N/A
Cedar	3,077	7637	1,276	$32,844,892	0.167081315	N/A
Chariton	N/A	4547	N/A	N/A	N/A	N/A
Christian	1,716	32572	524	$755,882	0.016087437	N/A
Clark	2,027	3739	519	$9,520,300	0.138807168	N/A
Clay	13,977	96960	2,714	$529,660,735	0.027990924	N/A
Clinton	N/A	9581	954	$87,279,208	0.09957207	N/A

County	Population Impacted	Total Buildings	Buildings Impacted	Approximate Value Affected	Earthquake Loss Ratio (based on exposure)	Comments
Cole	N/A	35469	N/A	N/A	N/A	N/A
Cooper	N/A	8222	N/A	N/A	N/A	N/A
Crawford	N/A	12709	N/A	N/A	N/A	N/A
Dade	N/A	4202	N/A	N/A	N/A	N/A
Dallas	N/A	7930	N/A	N/A	N/A	N/A
Daviess	N/A	4613	N/A	N/A	N/A	N/A
DeKalb	N/A	4700	N/A	$5,000	N/A	N/A
Dent	N/A	7678	N/A	N/A	N/A	N/A
Douglas	N/A	6667	N/A	N/A	N/A	N/A
Dunklin	21129	15832	7072	$228,609,835	0.446690248	0.15
Franklin	105,048	46470	32,886	$2,536,140,312	0.707682376	N/A
Gasconade	N/A	8894	N/A	N/A	N/A	N/A
Gentry	6,861	3560	3,214	$220,200,000	0.902808989	N/A
Greene	58,086	130805	15887	$3,416,795,720	0.121455602	N/A
Grundy	N/A	5567	N/A	N/A	N/A	N/A
Harrison	N/A	4904	N/A	N/A	N/A	N/A
Henry	N/A	11861	N/A	N/A	N/A	N/A
Hickory	N/A	6970	N/A	N/A	N/A	N/A
Holt	2,729	3144	679	$35,695,250	0.215966921	N/A
Howard	N/A	5092	N/A	$27,000	N/A	N/A
Howell	406	19398	19,509	$29,862,380	1.005722239	N/A
Iron	N/A	5568	N/A	N/A	N/A	N/A
Jackson	67,020	332094	12,161	$1,808,796,880	0.03661915	N/A
Jasper	1,168	54293	527	$206,200	0.009706592	N/A
Jefferson	183,725	91200	51,087	$4,586,910,000	0.560164474	N/A
Johnson	65,269	22848	25543	$658,000,000	1.117953431	N/A
Knox	309	2478	92	$4,980,816	0.037126715	N/A
Laclede	N/A	16959	N/A	N/A	N/A	N/A
Lafayette	9,882	15990	7,073	$199,857,930	0.442338962	N/A
Lawrence	N/A	17572	N/A	N/A	N/A	N/A
Lewis	1,250	4935	525	$9,682,814	0.106382979	N/A
Lincoln	N/A	21589	N/A	N/A	N/A	N/A
Linn	N/A	7193	N/A	N/A	N/A	N/A
Livingston	N/A	7374	N/A	N/A	N/A	N/A
Macon	1,655	10317	590	$96,100,000	0.057187167	N/A
Madison	1,098	8434	323	$17,239,787	0.038297368	N/A

County	Population Impacted	Total Buildings	Buildings Impacted	Approximate Value Affected	Earthquake Loss Ratio (based on exposure)	Comments
Maries	N/A	6382	N/A	N/A	N/A	N/A
Marion	5,812	4815	1,996	$360,000,000	0.414537902	N/A
McDonald	473	13969	137	$16,095,775	0.009807431	N/A
Mercer	N/A	2266	N/A	N/A	N/A	N/A
Miller	0	13585	4,158	$142,380	0.306072874	N/A
Mississippi	7633	6211	4162	$237,809,328	0.670101433	N/A
Moniteau	N/A	6714	N/A	$53,000	N/A	N/A
Monroe	978	5187	389	$56,800,000	0.07499518	N/A
Montgomery	N/A	6784	N/A	N/A	N/A	N/A
Morgan	1,931	16239	88	$2,933	0.005419053	N/A
New Madrid	12641	9233	3998	$695,048,426	0.433012022	N/A
Newton	561	26042	257	$71,000	0.009868674	N/A
Nodaway	N/A	10362	773	$5,827,842	0.074599498	N/A
Oregon	6,135	5711	2,325	$125,545,509	0.407109088	N/A
Osage	N/A	6849	N/A	N/A	N/A	N/A
Ozark	4,488	5805	1,950	$77,018,883	0.335917313	N/A
Pemiscot	15163	8940	4013	$77,566,127	0.448881432	N/A
Perry	N/A	9167	N/A	N/A	N/A	N/A
Pettis	N/A	19710	N/A	$127,000	N/A	0.003
Phelps	N/A	20881	N/A	N/A	N/A	N/A
Pike	3,772	8610	1,235	$213,000,000	0.143437863	N/A
Platte	4,393	40468	778	$197,811,383	0.019225067	N/A
Polk	N/A	14247	N/A	N/A	N/A	N/A
Pulaski	N/A	18683	N/A	N/A	N/A	N/A
Putnam	N/A	3010	N/A	N/A	N/A	N/A
Ralls	2,005	5529	793	$100,000,000	0.143425574	N/A
Randolph	2,589	11558	876	$146,100,000	0.075791659	N/A
Ray	704	10709	187	$33,609,181	0.017461948	N/A
Reynolds	19,776	4174	6,324	$137,089,246	1.515093436	N/A
Ripley	N/A	6869	N/A	N/A	N/A	N/A
Saline	2,901	10935	1,303	$219,233,200	0.119158665	N/A
Schuyler	251	2527	106	$4,314,022	0.041946973	N/A
Scotland	274	2525	117	$4,389,754	0.046336634	N/A
Scott	22258	18578	6486	$661,857,204	0.349122618	N/A
Shannon	N/A	4299	N/A	N/A	N/A	N/A
Shelby	714	3709	268	$42,800,000	0.072256673	N/A

County	Population Impacted	Total Buildings	Buildings Impacted	Approximate Value Affected	Earthquake Loss Ratio (based on exposure)	Comments
St. Charles	275,154	144865	66,748	$86,523,600,903	0.460760018	N/A
St. Clair	N/A	5891	N/A	N/A	N/A	N/A
St. Francois	N/A	29745	N/A	N/A	N/A	N/A
St. Louis	1,219,567	187725	416,566	$55,388,494,260	2.219022506	N/A
St. Louis City*	523,990	463317	97,243	$14,810,590,110	0.209884377	N/A
Ste. Genevieve	N/A	9175	N/A	N/A	N/A	N/A
Stoddard	16,899	14835	9,481	$425,308,708	0.639096731	N/A
Stone	N/A	20352	N/A	N/A	N/A	N/A
Sullivan	N/A	3661	5	$12,641,000	0.001365747	N/A
Taney	N/A	29298	N/A	$52,330,349	N/A	N/A
Texas	8,761	12596	3,515	$195,415,523	0.279056843	N/A
Vernon	N/A	10122	N/A	N/A	N/A	N/A
Warren	N/A	15173	N/A	N/A	N/A	N/A
Washington	N/A	11285	N/A	N/A	N/A	N/A
Wayne	27,724	8352	7,895	$88,778,876	0.945282567	N/A
Webster	22,673	15027	9415	$111,477,710	0.626538897	N/A
Worth	543	1300	985	$30,477,750	0.757692308	N/A
Wright	8,608	9285	2,629	$167,112,931	0.283144857	N/A

Legend: The counties highlighted in blue did not have an approved plan at the time this report was developed. The county names highlighted in yellow denote counties that had either new or updated plans since the 2010 State Mitigation Plan update

Table 3.6.2c Local Plan Tornado Loss Estimate Summary

County	Population Impacted	Total Buildings	Buildings Impacted	Approximate Value Affected	Tornado Loss Ratio (based on exposure)	Comments
Adair	N/A	11986	N/A	N/A	N/A	N/A
Andrew	range 0-500	7791	N/A	$153,024,795	N/A	N/A
Atchison	3,215	3344	1,550	$162,900,000	0.463516746	N/A
Audrain	6,786	11915	2,243	$385,400,000	0.188250105	N/A
Barry	1,084	18297	16	$26,552,042	0.00087446	N/A
Barton	2,508	6247	1,322	$1,739,350,031	0.211621578	N/A
Bates	N/A	8273	N/A	N/A	N/A	N/A
Benton	N/A	14363	N/A	N/A	N/A	N/A
Bollinger	N/A	6060	N/A	N/A	N/A	N/A
Boone	N/A	73126	N/A	N/A	N/A	N/A

County	Population Impacted	Total Buildings	Buildings Impacted	Approximate Value Affected	Tornado Loss Ratio (based on exposure)	Comments
Buchanan	range 0-500	41140	N/A	$772,217,289	N/A	N/A
Butler	N/A	21070	1,104	$107,569,600	0.052396773	N/A
Caldwell	N/A	5025	279	$9,180,000	0.055522388	N/A
Callaway	N/A	19592	N/A	N/A	N/A	N/A
Camden	7,410	41337	9,671	$988,477,044	0.233955052	N/A
Cape Girardeau	6,274	34908	1615	$141,000,048	0.046264467	N/A
Carroll	N/A	5094	N/A	N/A	N/A	N/A
Carter	N/A	3378	N/A	N/A	N/A	N/A
Cass	12,970	41880	3,115	$612,932,704	0.074379179	N/A
Cedar	3,440	7637	1,633	$32,540,851	0.213827419	N/A
Chariton	N/A	4547	N/A	N/A	N/A	N/A
Christian	14,148	32572	2089	$80,031,850	0.06413484	N/A
Clark	2,857	3739	799	$36,020,100	0.213693501	N/A
Clay	34,941	96960	6,785	$1,324,151,837	0.06997731	N/A
Clinton	N/A	9581	954	$87,279,208	0.09957207	N/A
Cole	N/A	35469	N/A	N/A	N/A	N/A
Cooper	N/A	8222	N/A	N/A	N/A	N/A
Crawford	N/A	12709	N/A	N/A	N/A	N/A
Dade	N/A	4202	N/A	N/A	N/A	N/A
Dallas	N/A	7930	N/A	N/A	N/A	N/A
Daviess	N/A	4613	N/A	N/A	N/A	N/A
DeKalb	N/A	4700	722	$76,054,500	0.153617021	N/A
Dent	N/A	7678	N/A	N/A	N/A	N/A
Douglas	N/A	6667	N/A	N/A	N/A	N/A
Dunklin	11234	15832	4628	$114,720,406	0.292319353	N/A
Franklin	9,022	46470	2,744	$219,740,026	0.059048849	N/A
Gasconade	N/A	8894	1,222	N/A	0.137395997	N/A
Gentry	3,431	3560	1,607	$156,000,000	0.451404494	N/A
Greene	77,448	130805	21180	$4,555,717,628	0.161920416	N/A
Grundy	N/A	5567	N/A	N/A	N/A	N/A
Harrison	N/A	4904	N/A	N/A	N/A	N/A
Henry	N/A	11861	N/A	N/A	N/A	N/A
Hickory	N/A	6970	N/A	N/A	N/A	N/A
Holt	1,561	3144	390	$20,217,286	0.124045802	N/A
Howard	N/A	5092	N/A	$3,031,177	N/A	N/A
Howell	1,006	19398	19,520	$202,575,533	1.006289308	N/A

County	Population Impacted	Total Buildings	Buildings Impacted	Approximate Value Affected	Tornado Loss Ratio (based on exposure)	Comments
Iron	N/A	5568	N/A	N/A	N/A	N/A
Jackson	134,042	332094	24,321	$3,617,593,760	0.073235289	N/A
Jasper	9,734	54293	4,372	$242,773,000	0.080526035	N/A
Jefferson	14,912	91200	4,185	$373,411,750	0.045888158	N/A
Johnson	7,239	22848	2833	$72,000,000	0.123993347	N/A
Knox	1,141	2478	460	$25,015,508	0.185633575	N/A
Laclede	N/A	16959	N/A	N/A	N/A	N/A
Lafayette	11,529	15990	8,252	$233,167,675	0.516072545	N/A
Lawrence	N/A	17572	N/A	N/A	N/A	N/A
Lewis	2,620	4935	981	$50,381,000	0.198784195	N/A
Lincoln	N/A	21589	N/A	N/A	N/A	N/A
Linn	N/A	7193	N/A	N/A	N/A	N/A
Livingston	N/A	7374	N/A	N/A	N/A	N/A
Macon	4,138	10317	1,475	$240,100,000	0.142967917	N/A
Madison	1,098	8434	323	$17,239,787	0.038297368	N/A
Maries	N/A	6382	N/A	N/A	N/A	N/A
Marion	2,905	4815	998	$180,000,000	0.207268951	N/A
McDonald	17,015	13969	5,077	$523,289,005	0.363447634	N/A
Mercer	N/A	2266	N/A	N/A	N/A	N/A
Miller	5,903	13585	4,324	$175,454,133	0.318292234	N/A
Mississippi	3640	6211	1996	$111,733,110	0.32136532	N/A
Moniteau	N/A	6714	N/A	$3,653,460	N/A	N/A
Monroe	2,444	5187	970	$142,100,000	0.187005976	N/A
Montgomery	N/A	6784	N/A	N/A	N/A	N/A
Morgan	4,616	16239	1,551	$231,584,064	0.095510807	N/A
New Madrid	6032	9233	1889	$330,245,447	0.204592224	N/A
Newton	4,677	26042	1,278	$254,392	0.049074572	N/A
Nodaway	N/A	10362	773	$5,827,842	0.074599498	N/A
Oregon	2,778	5711	1,175	$57,322,494	0.205743302	N/A
Osage	N/A	6849	N/A	N/A	N/A	N/A
Ozark	1,246	5805	603	$22,863,661	0.103875969	N/A
Pemiscot	7000	8940	1873	$27,447,906	0.20950783	N/A
Perry	N/A	9167	N/A	N/A	N/A	N/A
Pettis	8,448	19710	4,155	$708,520,000	0.210806697	N/A
Phelps	N/A	20881	4,772	N/A	0.228533116	N/A
Pike	1,886	8610	616	$106,900,000	0.071544715	N/A

County	Population Impacted	Total Buildings	Buildings Impacted	Approximate Value Affected	Tornado Loss Ratio (based on exposure)	Comments
Platte	14,643	40468	2,595	$659,371,278	0.064124741	N/A
Polk	N/A	14247	N/A	N/A	N/A	N/A
Pulaski	N/A	18683	4,215	N/A	0.225606166	N/A
Putnam	N/A	3010	N/A	N/A	N/A	N/A
Ralls	1,001	5529	400	$49,000,000	0.072345813	N/A
Randolph	6,474	11558	2,188	$365,200,000	0.189306108	N/A
Ray	3,518	10709	934	$168,045,905	0.08721636	N/A
Reynolds	12,363	4174	3,954	$85,680,784	0.947292765	N/A
Ripley	N/A	6869	N/A	N/A	N/A	N/A
Saline	4,927	10935	2,580	$425,160,000	0.235939643	N/A
Schuyler	1,254	2527	1526	$21,570,118	0.603878116	N/A
Scotland	2,171	2525	586	$21,948,772	0.232079208	N/A
Scott	10308	18578	3731	$118,352,003	0.200828937	N/A
Shannon	N/A	4299	N/A	N/A	N/A	N/A
Shelby	3,570	3709	1340	$214,200,000	0.361283365	N/A
St. Charles	23,113	144865	5,585	$1,015,293,140	0.038553136	N/A
St. Clair	N/A	5891	N/A	N/A	N/A	N/A
St. Francois	N/A	29745	N/A	N/A	N/A	N/A
St. Louis	87,827	187725	19,336	$3,586,852,937	0.103001731	N/A
St. Louis City*	33,432	463317	6,107	$574,931,000	0.01318104	N/A
Ste. Genevieve	N/A	9175	N/A	N/A	N/A	N/A
Stoddard	8,096	14835	4,519	$202,254,954	0.304617459	N/A
Stone	N/A	20352	N/A	N/A	N/A	N/A
Sullivan	N/A	3661	9	$25,279,000	0.002458345	N/A
Taney	N/A	29298	N/A	$523,303,502	N/A	N/A
Texas	15,274	12596	4,518	$232,862,315	0.358685297	N/A
Vernon	N/A	10122	N/A	N/A	N/A	N/A
Warren	N/A	15173	N/A	N/A	N/A	N/A
Washington	N/A	11285	N/A	N/A	N/A	N/A
Wayne	17,331	8352	4,937	$55,486,799	0.5911159	N/A
Webster	4,610	15027	821	$47,283,261	0.05463499	N/A
Worth	434	1300	381	$2,440,000	0.293076923	N/A
Wright	4,239	9285	1,142	$80,232,143	0.122994076	N/A

Legend: The counties highlighted in blue did not have an approved plan at the time this report was developed. The county names highlighted in yellow denote counties that had either new or updated plans since the 2010 State Mitigation Plan update

[Figure 3.6.2.1](#) through [3.6.2.12](#) convey this summary data in thematic maps for persons impacted, buildings impacted, and potential dollar loss respectively.

Figure 3.6.2.1 - Local Plan Flood Risk Summary: Persons Impacted

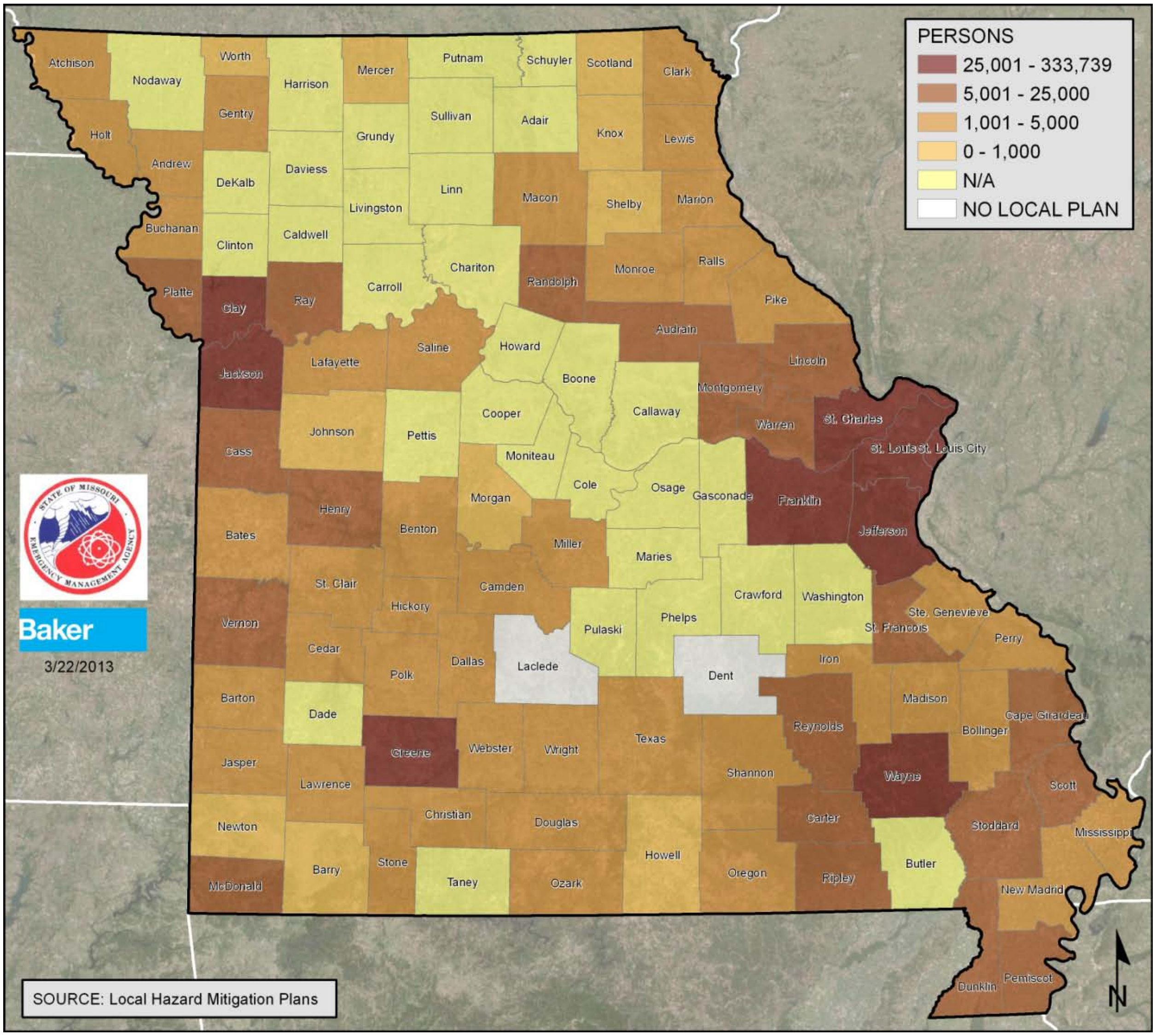


Figure 3.6.2.2 - Local Plan Flood Risk Summary: Buildings Impacted

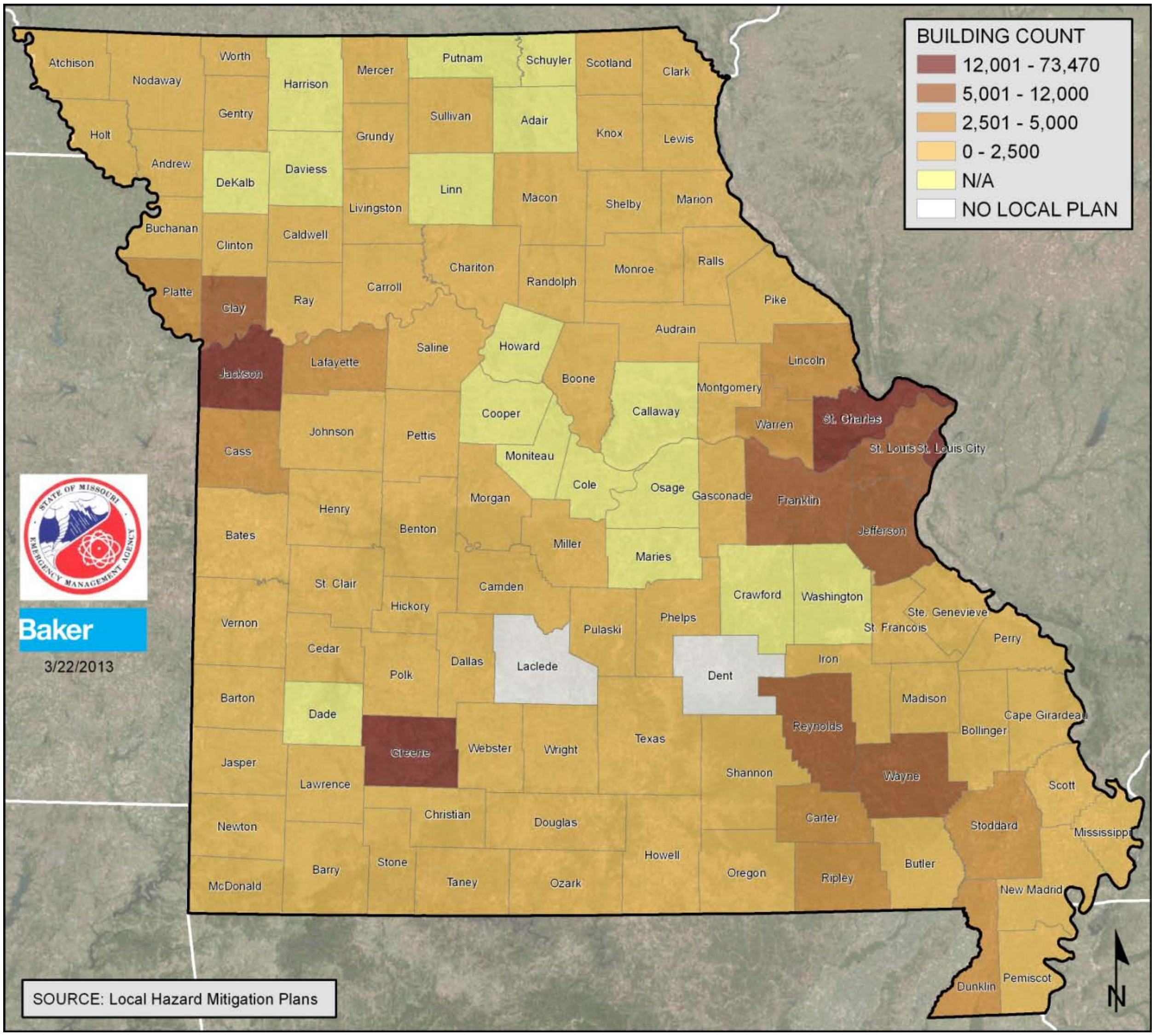


Figure 3.6.2.3 - Local Plan Flood Risk Summary: Potential $ Loss

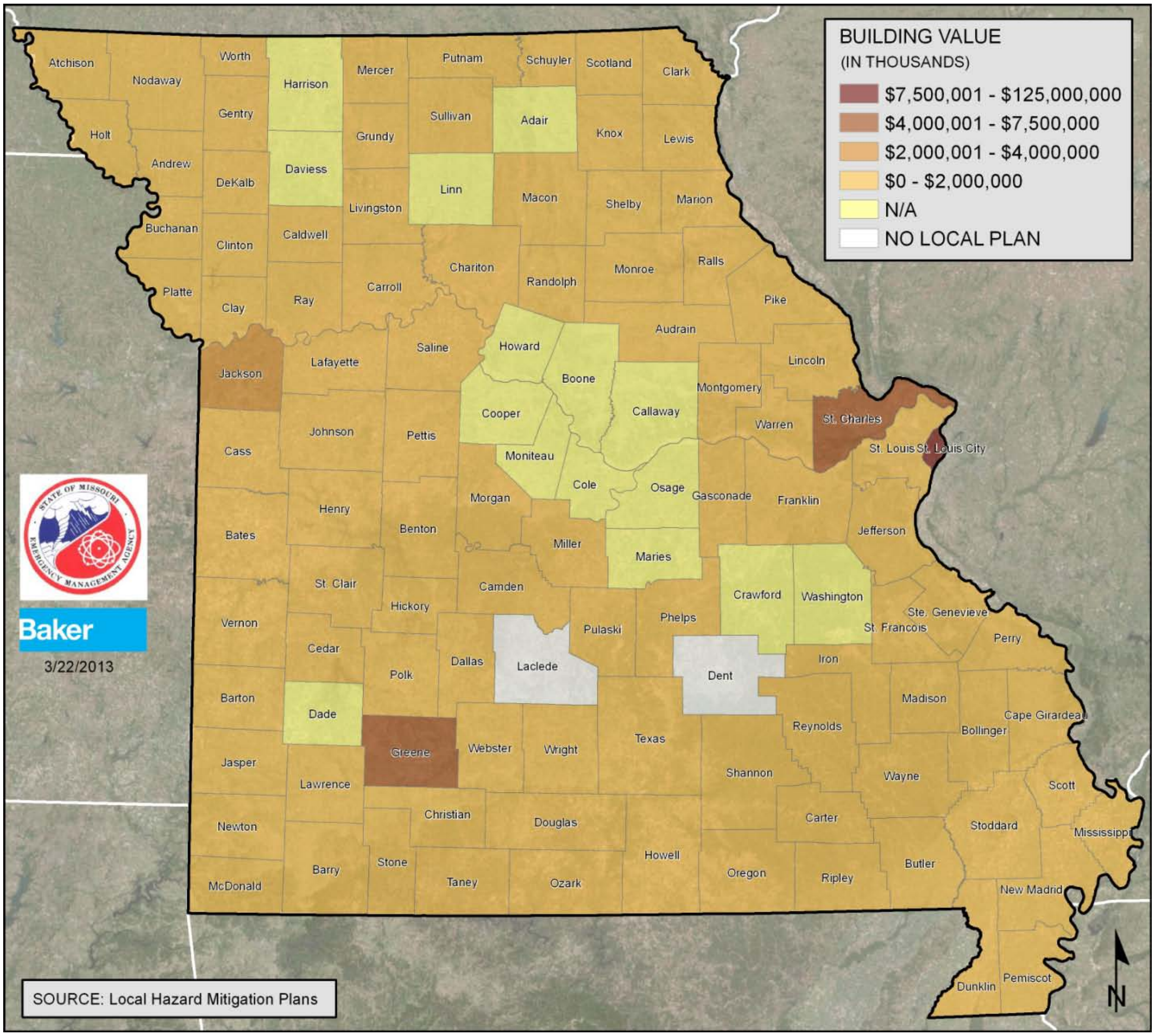


Figure 3.6.2.4 - Local Plan Flood Risk Summary: Potential Building Loss Ratio

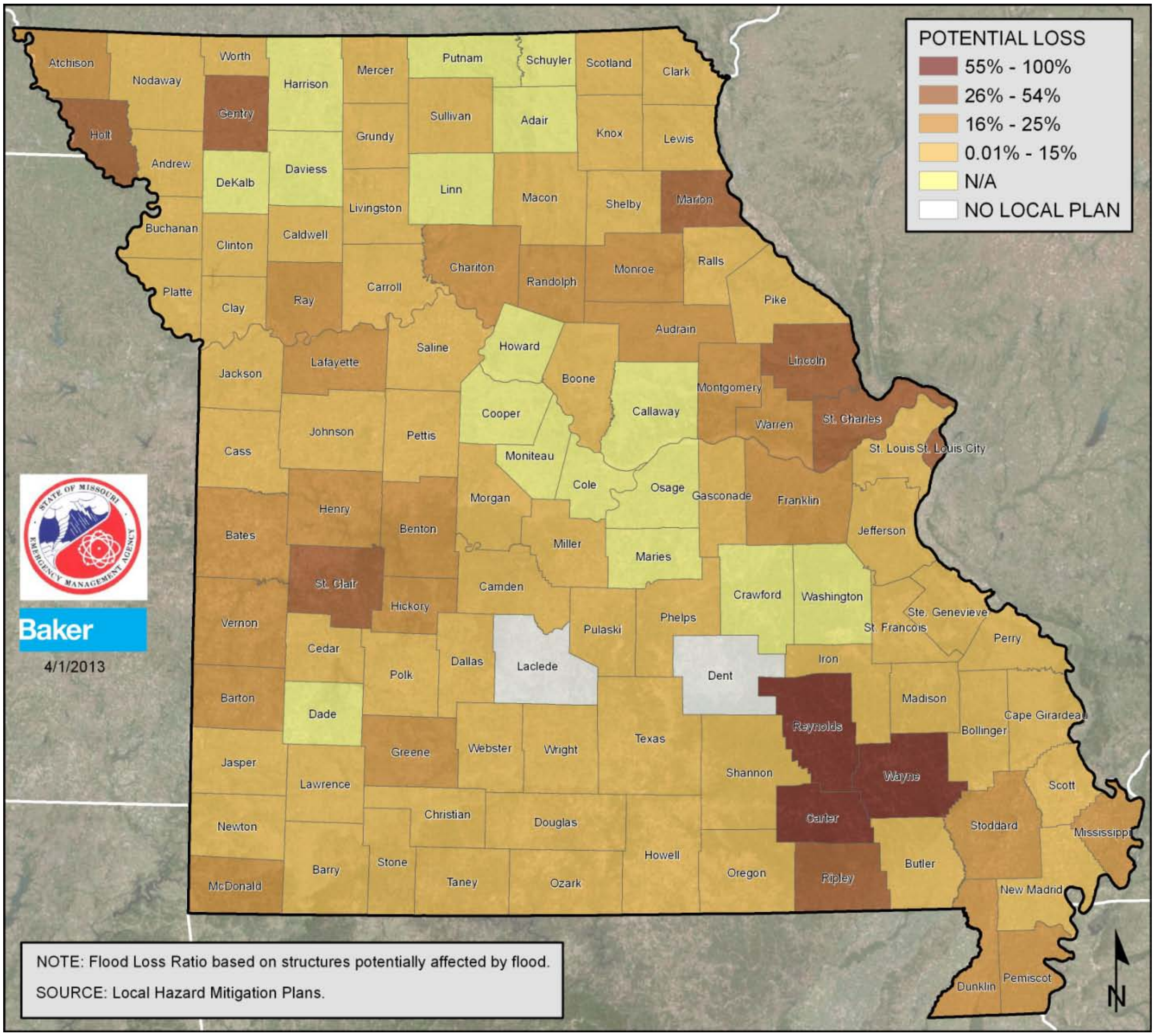


Figure 3.6.2.5 - Local Plan Earthquake Risk Summary: Persons Impacted

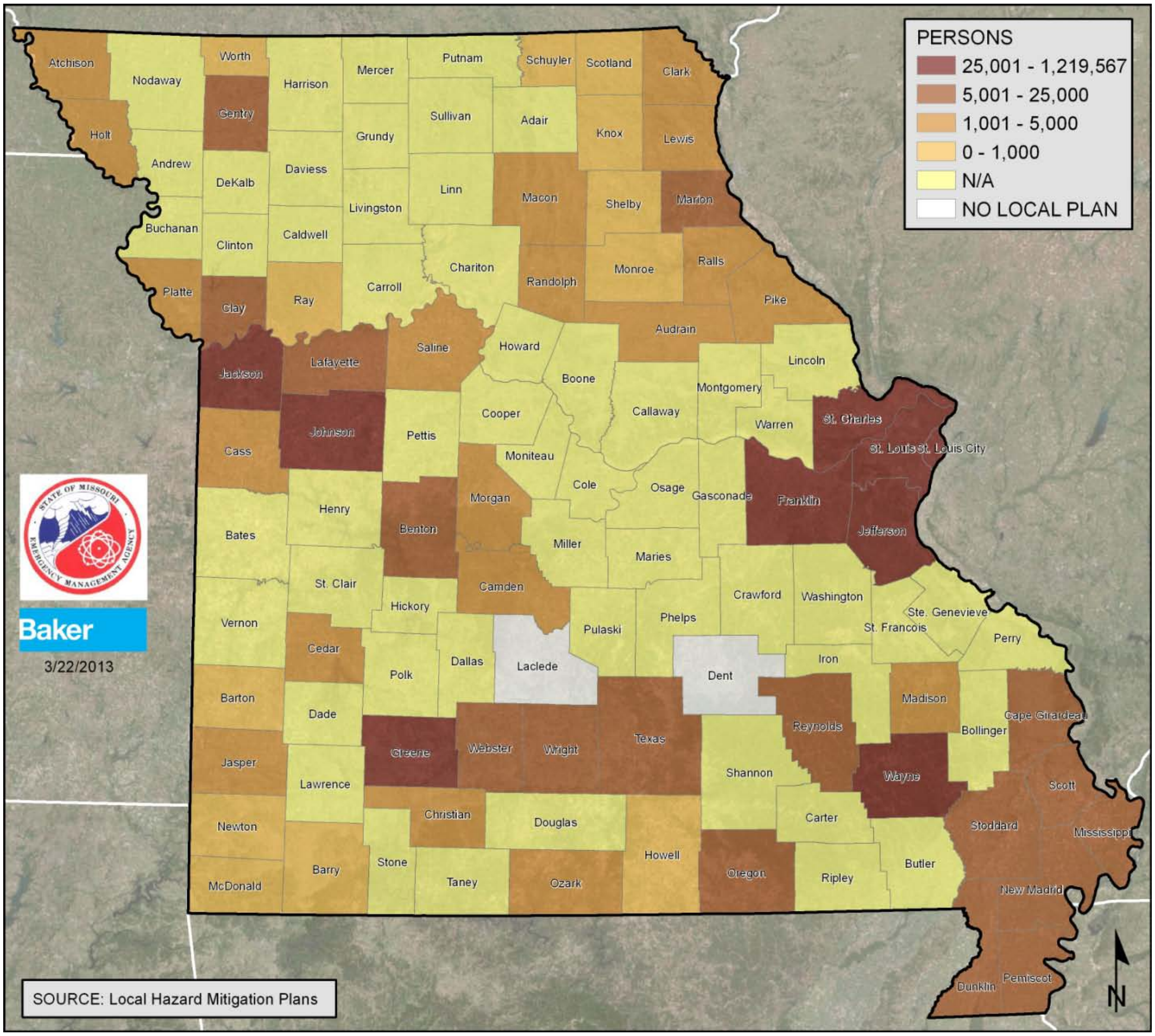


Figure 3.6.2.6 - Local Plan Earthquake Risk Summary: Buildings Impacted

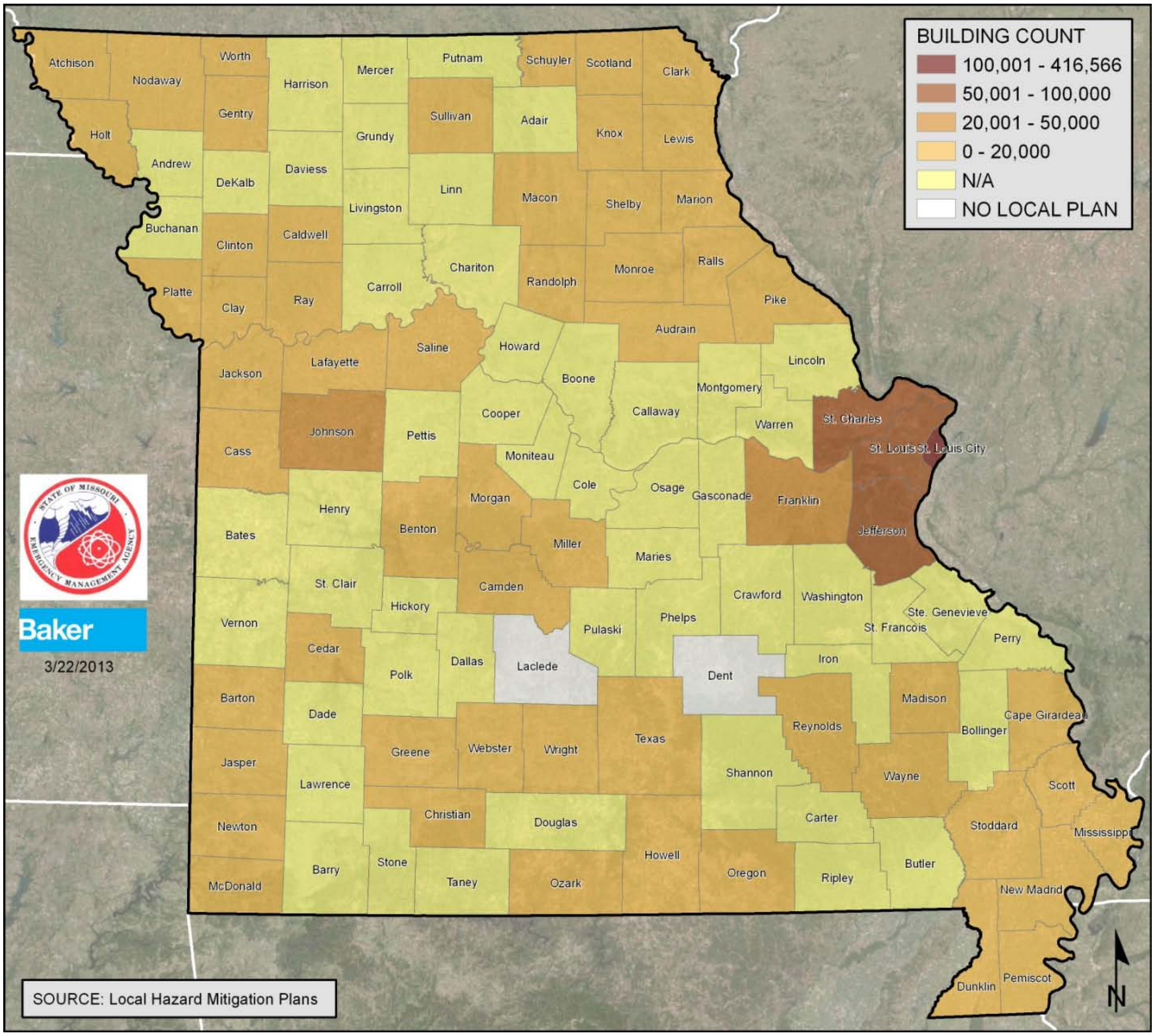


Figure 3.6.2.7 - Local Plan Earthquake Risk Summary: Potential $ Loss

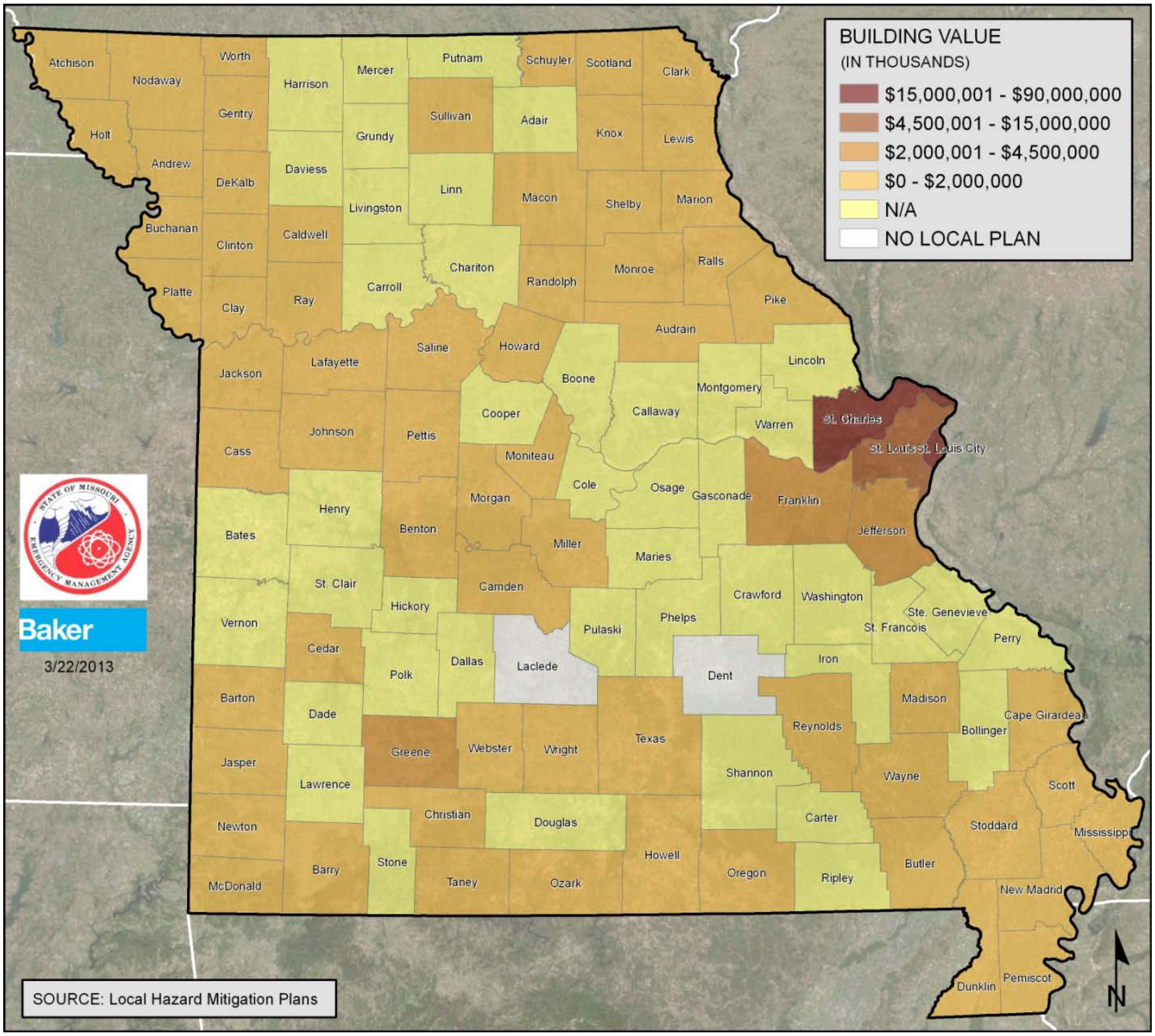


Figure 3.6.2.8 - Local Plan Earthquake Risk Summary: Potential Building Loss Ratio

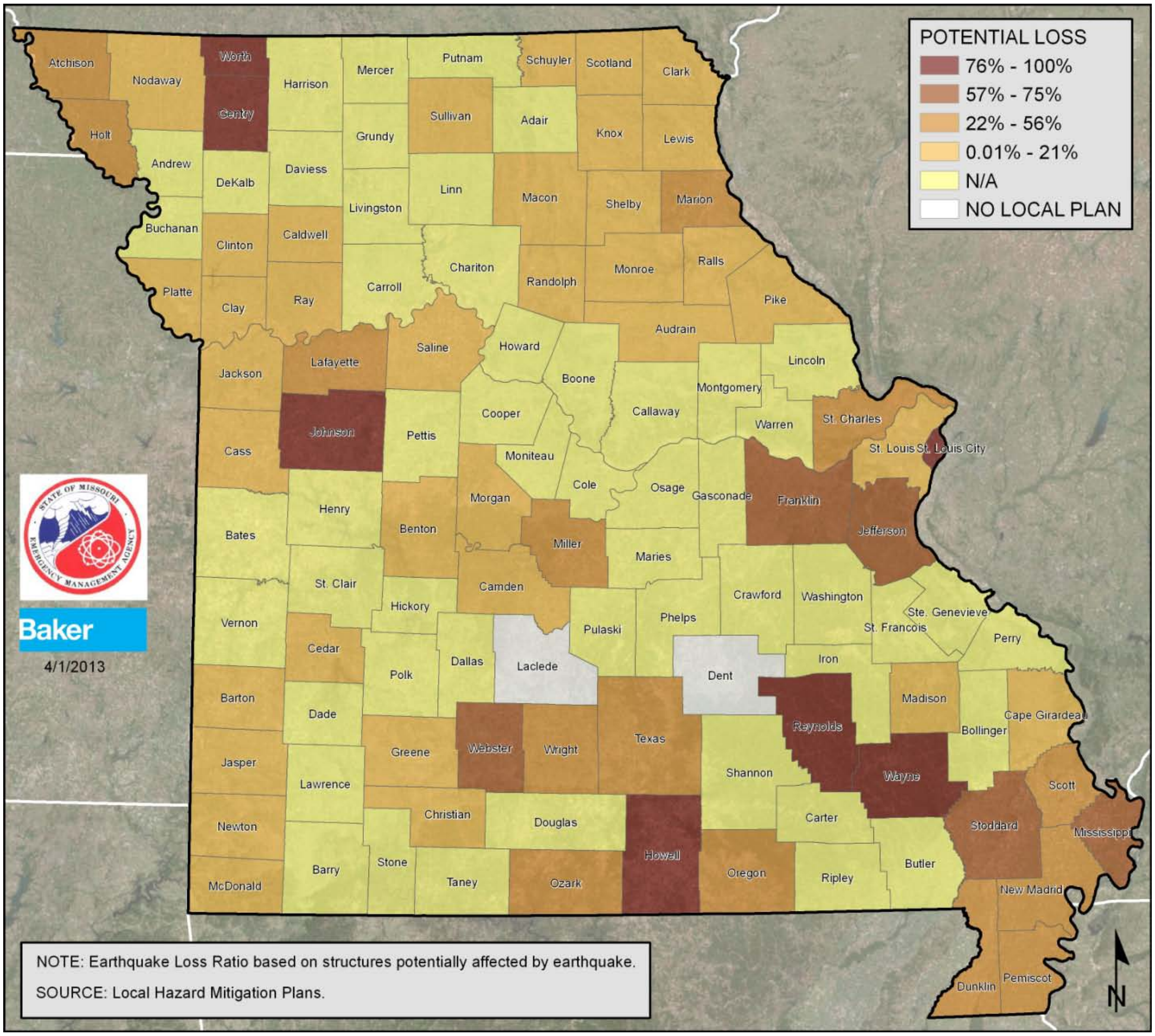


Figure 3.6.2.9 - Local Plan Tornado Risk Summary: Persons Impacted

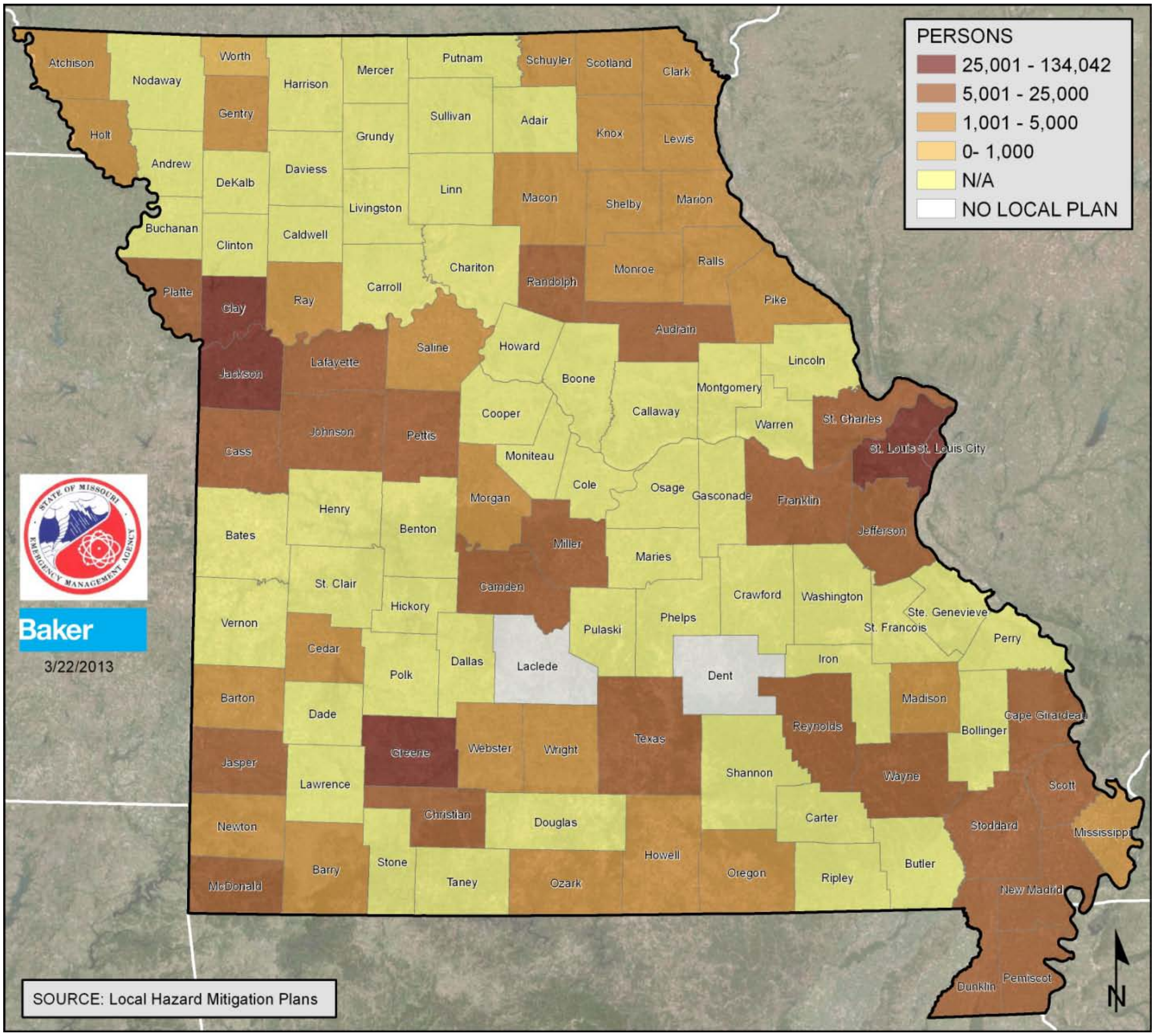


Figure 3.6.2.10 - Local Plan Tornado Risk Summary: Buildings Impacted

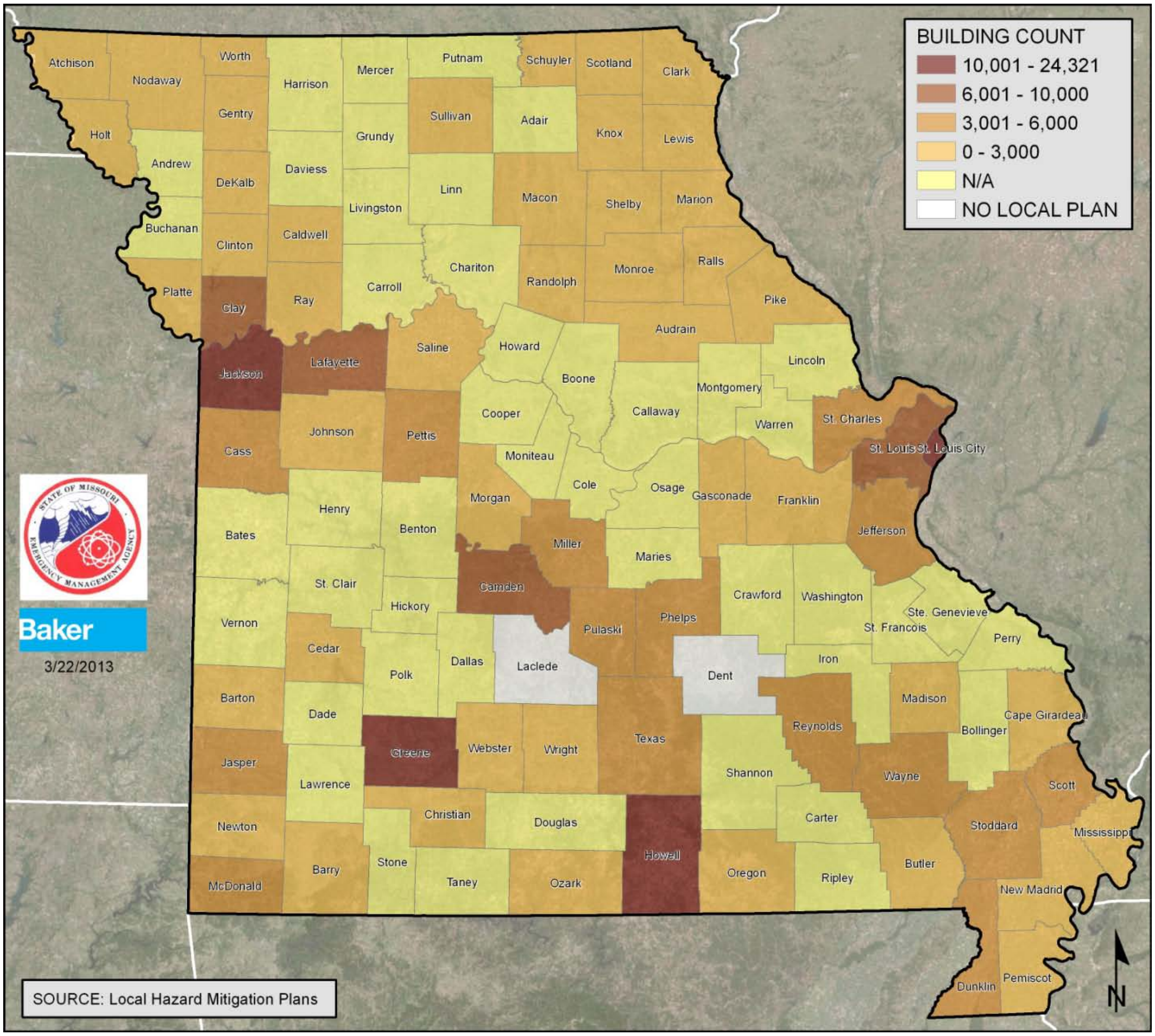


Figure 3.6.2.11 - Local Plan Tornado Risk Summary: Potential $ Loss

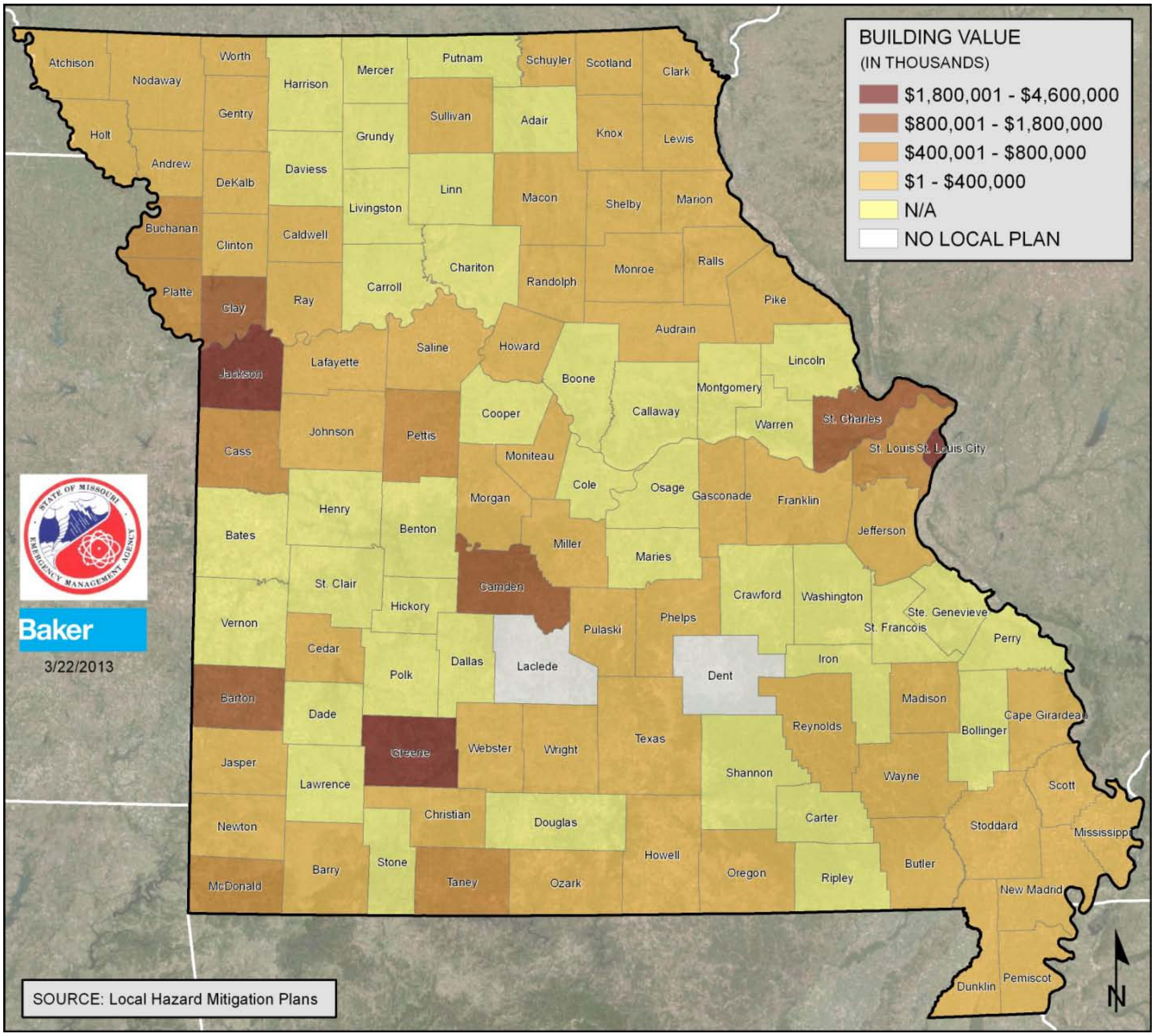
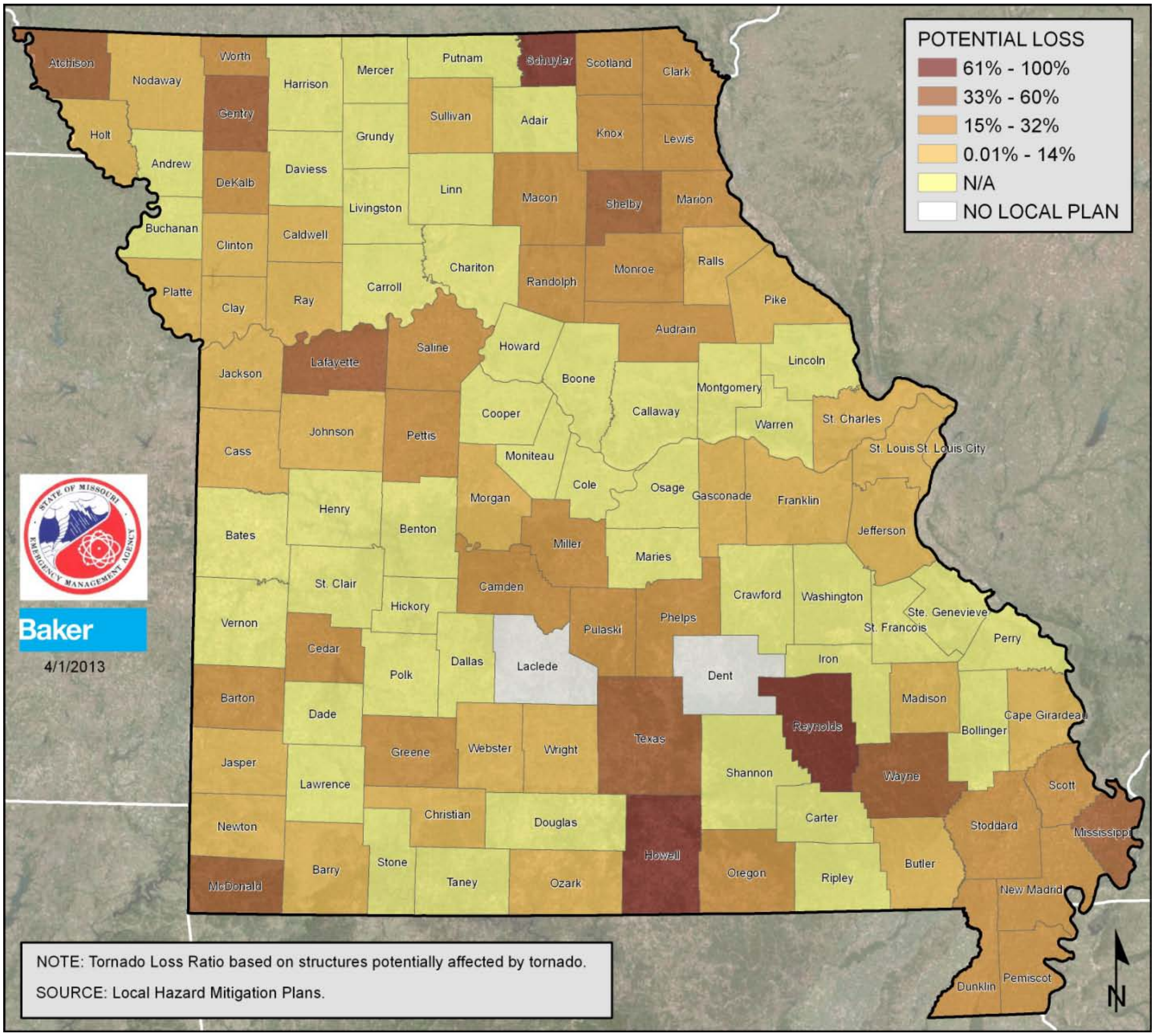


Figure 3.6.2.12 - Local Plan Tornado Risk Summary: Potential Building Loss Ratio



3.7 Assessing Vulnerability and Estimating Potential Losses of State Owned or Operated Facilities

Requirements §201.4(c)(2)(ii) and §201.4(c)(2)(iii):	[The state risk assessment shall include an overview and analysis of the state's vulnerability to the hazards described in this paragraph (c)(2), based on estimates provided in] the state risk assessment. **State owned critical or operated facilities located in the identified hazard areas shall also be addressed.** [The State risk assessment shall include an] overview and analysis of potential losses to the identified vulnerable structures, based on estimates provided in local risk assessments as well as the State risk assessment. **The State shall estimate the potential dollar losses to State owned or operated buildings, infrastructure, and critical facilities located in the identified hazard areas.**

Figure 3.7.1 - Missouri State Capital Building

Source: www.visitmo.com

As Missouri remains vulnerable to natural hazards, state-owned or operated facilities are at risk to incur damage from hazard events. The state's resources, both monetary and fixed assets, depend heavily upon these facilities and their continuity. This section assesses vulnerability and potential losses to state-owned or operated facilities. According to the regulatory requirements of the Disaster Mitigation Act, the State must provide an overview vulnerability analysis and loss estimates for state-owned or operated buildings, infrastructure, and critical facilities located in the identified hazard areas. To perform this analysis, identified hazard areas exist for the following hazards: dam failure, earthquake, flood, and levee failure. Therefore, for those hazards, a more comprehensive analysis was completed, including loss estimates. For the remaining hazards, clearly identified hazard areas are not established

due to data limitations (as with the levee failure hazard) or the random nature of the hazard (as with severe thunderstorms). For these hazards, where appropriate, the State has utilized the statewide vulnerability analysis to identify state-owned facilities within counties indicated to have increased vulnerability. For some of the hazards addressed, a narrative is provided to discuss vulnerability of state-owned facilities. Where data is available, vulnerability and loss estimation are described in more detail by hazard in this section. Table 3.7a summarizes the updates in this section for each hazard profiled.

Table 3.7a Summary of Vulnerability Analysis/Loss Estimation Updates

Natural Hazards	2007	2010	2013
Riverine Flooding (Major and Flash)	None	Identified facilities (with GIS data) within floodplain and 5-mile downstream radius of state-regulated Class I or Class II dams.	GIS locations of updated State-owned facilities compared with HAZUS-generated floodplain (with integrated DFIRM depth grids where available) to determine number and exposure value of state-owned facilities in the 100-year floodplain.
Dam Failure	None	Narrative	Identified critical facilities (using GIS data) within Missouri DNR high risk dam inundation zones.
Levee Failure	HAZUS-MH	HAZUS-MH ground shaking data utilized to indicate vulnerable state-owned facilities (with GIS data)	Analysis of MLI and NLD data to determine locations of state-owned facilities in proximity to all levees known to provide protection against 100-year flood.
Earthquakes	None	Utilized results of statewide vulnerability analysis to identify state-owned facilities within counties indicated to have increased vulnerability.	HAZUS 2.1 USGS ground shaking data utilized to indicate vulnerable state-owned facilities (with GIS data).
Land Subsidence/Sinkholes	None	Narrative	Utilized results of updated statewide vulnerability analysis to identify state-owned facilities within counties indicated to have increased vulnerability.
Severe Thunderstorms	None	Utilized results of statewide vulnerability analysis to identify state-owned facilities within counties indicated to have increased vulnerability.	Utilized results of statewide vulnerability analysis to identify state-owned facilities within counties indicated to have increased vulnerability.
Tornadoes	None	Analysis of DFIRM data to determine locations of state-owned facilities in proximity to DFIRM levees (limited by available data)	Utilized results of statewide vulnerability analysis to identify state-owned facilities within counties indicated to have increased vulnerability.
Severe Winter Weather/Snow/Ice: North of MO River South of MO River	HAZUS-MH	GIS locations of available State-owned facilities compared with HAZUS-generated floodplain (with integrated DFIRM depth grids where available) to determine number and exposure value of state-owned facilities in the 100-year floodplain.	Utilized results of statewide vulnerability analysis to identify state-owned facilities within counties indicated to have increased vulnerability.

Natural Hazards	2007	2010	2013
Drought	None	Utilized results of statewide vulnerability analysis to identify state-owned facilities within counties indicated to have increased vulnerability.	Updated narrative.
Extreme Temperatures	None	Utilized results of statewide vulnerability analysis to identify state-owned facilities within counties indicated to have increased vulnerability.	Updated narrative.
Fires: Structural & Urban Wild	Statistical analysis of NCDC data	Utilized results of statewide vulnerability analysis to identify state-owned facilities within counties indicated to have increased vulnerability.	Utilized updated results of statewide vulnerability analysis to identify state-owned facilities within counties indicated to have increased vulnerability.
Manmade and Other Hazards	**2007**	**2010**	**2013**
Attack (Nuclear, Conventional, Chemical, and Biological)	None	Narrative	Narrative
Civil Disorder	None	Narrative	Updated Narrative
Cyber Disruption	N/A	N/A	Narrative
Hazardous Materials Release: Fixed facility accidents Transportation accidents	None	Summary of state-owned facilities that may contain hazardous materials (based on asset use)	Summary of updated state-owned facilities database that may contain hazardous materials (based on asset use).
Mass Transportation Accidents	None	Narrative	Updated Narrative
Nuclear Power Plants (Emergencies and Accidents)	None	Identified state-owned facilities in counties within 50 mile radius of nuclear power plants or in county with University Research Reactor	Updated Narrative
Public Health Emergencies/Environmental Issues	None	Narrative	Updated Narrative
Special Events	None	Narrative	Narrative
Terrorism	None	Narrative	Narrative
Utilities (Interruptions and System Failures)	None	Narrative	Updated Narrative

State Facilities and Infrastructure

In the 2007 Mitigation Plan update, vulnerability overview analysis and loss estimates were provided for flooding, earthquake, and tornado for a limited number of state-owned facilities. At that time, the State Office of Administration was in the beginning phases of creating a facility inventory with geo-referenced locations.

For the 2010 update, the Office of Administration's facilities inventory was largely complete. In addition, the State obtained inventories from other state departments that are not captured in the Office of Administration inventory.

As part of the 2013 update, major improvements to available facility and bridge data resulted in a greatly improved data set to base the vulnerability assessments and loss estimations from. A total of fourteen (14) State Department's facilities and infrastructure were included in this data set, consisting of 17,364 individual features. What proved most beneficial during the risk assessment analysis was the ability to geo-locate 70% (percent) more facilities and infrastructure, as compared to the data used for the 2010 analysis.

The ability to either acquire or assign replacement values and to assign a 'critical' designation to all of these state facilities and bridges also proved extremely valuable for the plan update. Further details concerning these methodologies are found later on in this section. This collective geodatabase allowed for a more refined and quantitative assessment of state exposure to the various hazards that it faces. Table 3.7b summarizes state-owned facilities data obtained for this 2013 plan update.

Table 3.7b State Facilities and Bridge Data Inventories

Source/Inventory	# of Facilities Geolocated (2010)	# of Facilities Geolocated (2013)
Office of Administration/State Facilities—includes the following: • Dept. of Agriculture (DOA) • Dept. of Corrections (DOC) • Dept. of Economic Development (DED) • Dept. of Elementary and Secondary Education – Special Education (DESE) • Dept. of Labor and Industrial Relations (DOLIR) • Dept. of Mental Health (DMH) • Dept. of Natural Resources (DNR) • Dept. of Public Safety (DPS) • Dept. of Revenue (DOR) • Dept. of Social Services (DOSS)	3,477 (Owned) 0 (Leased)	3,437 (Owned) 959 (Leased)
Missouri Department of Transportation (MoDOT) • Buildings • State Bridges	0 7,124	175 10,361
MO Spatial Data Information Service (MSDIS) • Department of Higher Education (DHE) • Department of Elementary and Secondary Education (DESE)	143	89 2,343
Missouri Department of Conservation (MDC)	0	0
Total	**10,744**	**17,364**

The State, through the Office of Administration (OA), manages the tracking of state-owned facilities. A summary of these facilities by county is provided in Figure 3.7.2. The Office of Administration also leases space in 947 facilities. Table 3.7c provides the number of leased facilities in each county.

The Missouri Department of Transportation (MoDOT) also manages its own state-owned facilities and bridges. Figure 3.7.4 shows the number of MoDOT facilities and bridges in their inventory.

In addition, the Missouri Department of Higher Education and Department (DHE) of Elementary and Secondary Education (DESE) similarly manage inventories of their respective state-owned inventories. Figure 3.7.5 shows the collective number of facilities managed by these agencies. This list also includes information from the Missouri Department of Conservation (MDC) that was not able to be referenced in any of the other preceding figures or tables because it is currently not available in a geospatial format.

Figure 3.7.2 - OA State-owned Facilities in Missouri

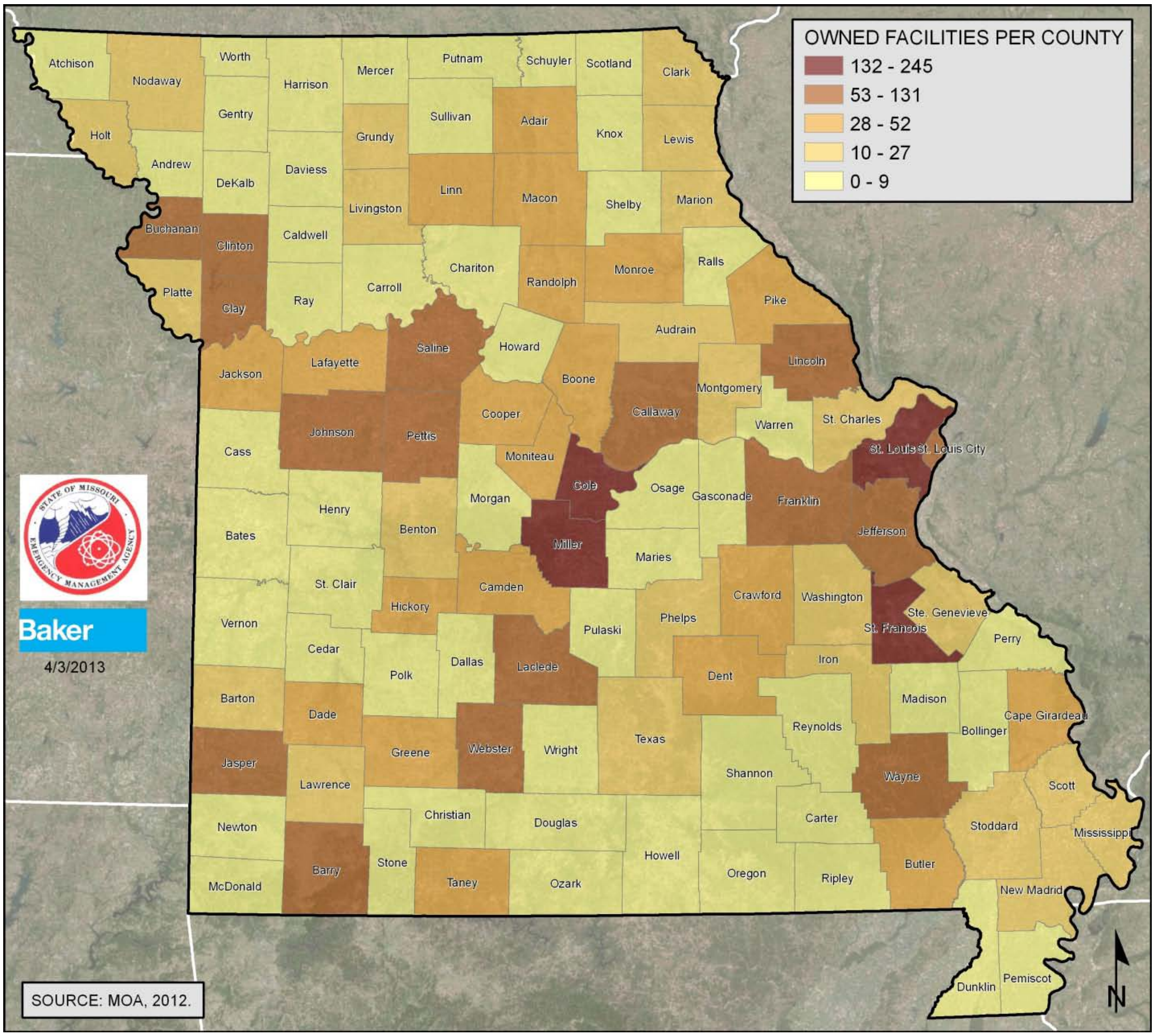


Figure 3.7.3 - OA State-leased Facilities in Missouri

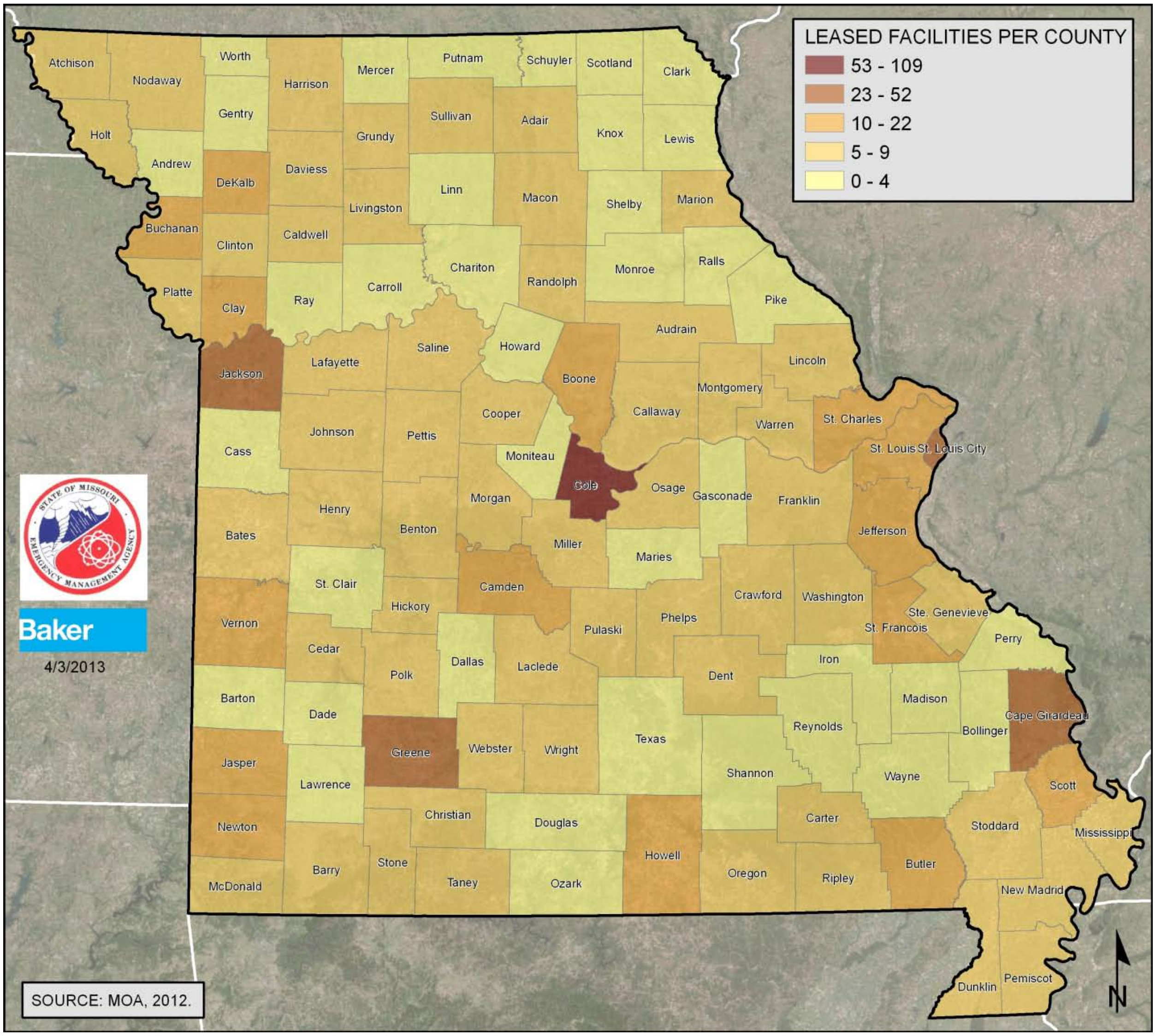


Figure 3.7.4 - MoDOT State-owned Facilities and Bridges in Missouri

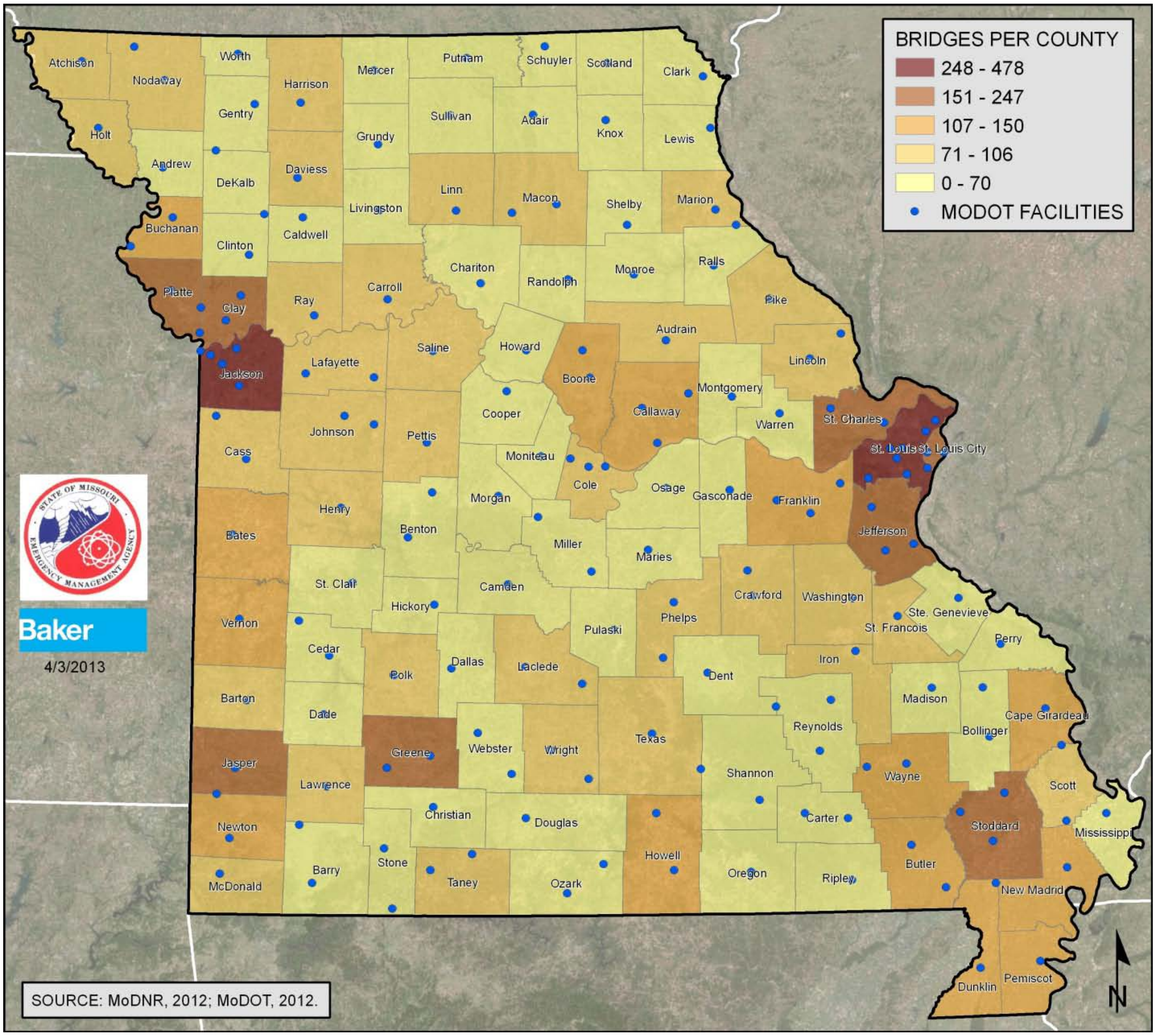
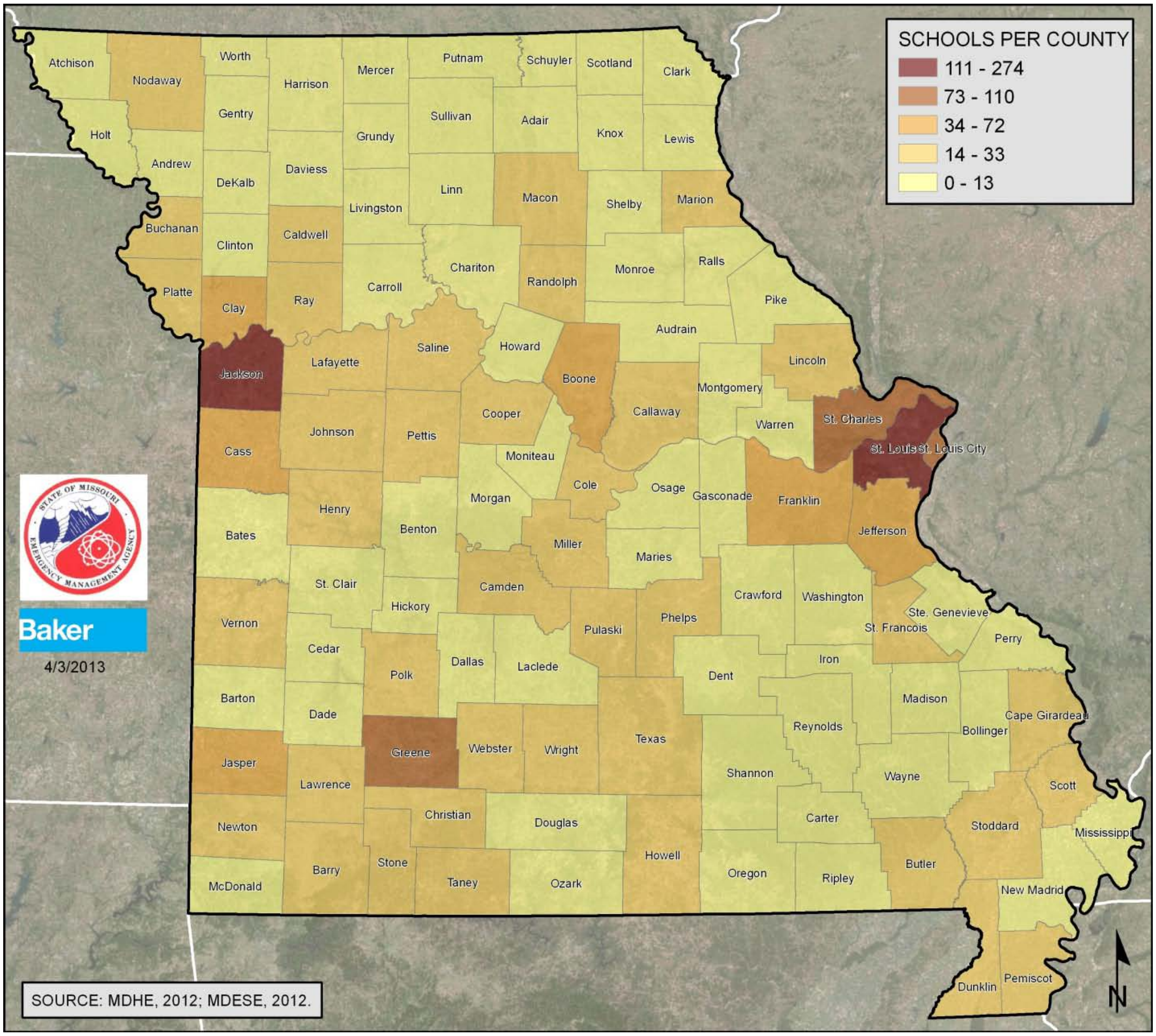


Figure 3.7.5 - Educational State-owned Facilities in Missouri



Building Valuation and Critical Facility Determination

As mentioned above, an important step that provided for additional, meaningful analysis was the determination of critical facilities from the inventories available. FEMA's Hazus loss estimation software uses the following three categories of critical assets. 'Essential facilities' are those that if damaged would have devastating impacts on disaster response and/or recovery. "High potential loss facilities" are those that would have a high loss or impact on the community. "Transportation and lifeline" facilities are third category of critical assets. For all of the facility and bridge data acquired, the State applied FEMA's guidelines for determining those that would be considered critical facilities.

In addition to both: 1) geolocating the State's facilities and infrastructure and 2) determining those termed 'critical', the State was able to assign a replacement cost for all of the applicable State inventories. This was the final pre-processing step performed on the facilities and infrastructure data, before many of the vulnerability assessments and loss estimations were able to be conducted.

OA State-Owned Facilities

For the OA managed State-owned facilities, FEMA's guidelines as detailed above, were utilized to determine those that should be considered as critical. The owned facility data provided by OA had 4 data fields for each facility that aided in this determination, including: Agency/Department, Facility Name, Asset Type, and space use. Of the 3,437 facilities that are owned, 963 met the FEMA categories that define a facility to be critical. This equates to 28% of the owned inventory. Replacement valuations were provided for each facility by OA.

OA State-Leased Facilities

For the OA managed State-leased facilities, FEMA's guidelines were again utilized to determine those that should be considered as critical. The leased facility data provided by OA had 3 data fields for each facility that aided in this determination, including: Agency, Organization, and space use. Of the 959 facilities that are leased, 64 met the FEMA categories that define a facility to be critical. This equates to 7% of the leased inventory. These leased facilities are the only state facilities where no replacement costs could be assigned, due to the fact that they are not owned by the State.

MoDOT State-Owned Facilities and Bridges

For the MoDOT managed State facilities and bridge inventories, all were considered critical, similarly to how they were classified during the 2010 plan update. This includes 175 MoDOT facilities and 10,361MoDOT bridges. Replacement valuations were conducted with the assistance of MoDOT staff, ensuring a completely populated data set.

Education State-Owned Facilities

For the educational facilities inventories, all were considered critical, just as they were classified during the 2010 plan update. This included 89 State facilities managed by DHE and 2,343 State facilities managed by DESE. Replacement valuations were not available at the time of the 2013 plan update. To allow for loss estimations to be performed on this data, replacement valuations were leveraged from Hazus's Level 1 building inventory data to arrive at an average replacement cost per facility.

Table 3.7c shows the State-wide summary, per county, of the facility geodatabase. Included in this table is the number of total state-owned facilities and those determined to be critical facilities, the number of state-owned bridges and those determined to be critical facilities, and the combined reported replacement cost. Table 3.7d shows this same information broken down by State Department. This list also includes information from the Missouri Department of Conservation (MDC) that was not able to be referenced in any of the other preceding figures or tables because it is currently not available in a geospatial format.

Table 3.7c State-Owned Facilities

County	State-Owned Facility and Bridge Replacement Values	Total # of State-Owned Facilities	State Owned # of Critical Facilities	Total # of State-leased facilities	State-leased Critical Facilities	State-Owned Bridges
Adair	$21,890,185	47	14	9	1	66
Andrew	$1,280,032	12	12	2	0	67
Atchison	$975,472	7	7	5	1	79
Audrain	$89,128,915	37	25	7	1	78
Barry	$21,786,910	90	32	6	1	55
Barton	$4,912,800	28	14	3	0	76
Bates	$3,278,428	20	15	7	0	112
Benton	$4,015,552	37	13	6	1	60
Bollinger	$1,768,208	11	11	3	0	65
Boone	$38,122,775	87	63	18	1	143
Buchanan	$178,133,413	120	62	14	0	150
Butler	$38,387,955	62	44	12	1	139
Caldwell	$1,462,768	15	15	5	0	51
Callaway	$246,409,535	120	65	6	0	123
Camden	$4,696,142	58	24	12	2	65
Cape Girardeau	$49,046,578	70	39	29	2	146
Carroll	$1,401,856	14	14	3	0	82
Carter	$1,524,560	7	7	5	1	43
Cass	$13,286,085	53	50	4	0	104
Cedar	$1,585,472	8	8	6	0	44
Chariton	$1,097,296	9	9	3	0	69
Christian	$2,498,272	32	32	6	0	51
Clark	$2,749,861	28	15	4	1	58
Clay	$36,045,911	143	103	15	1	247
Clinton	$148,630,505	81	25	5	0	50
Cole	$864,026,607	274	121	108	0	96
Cooper	$50,329,756	60	35	6	0	68
Crawford	$5,091,765	44	12	5	1	84
Dade	$4,251,964	44	11	4	0	54
Dallas	$1,097,296	9	9	4	0	53
Daviess	$1,219,120	11	11	5	2	75
DeKalb	$9,051,563	12	10	11	0	53
Dent	$8,555,404	55	15	5	1	59

County	State-Owned Facility and Bridge Replacement Values	Total # of State-Owned Facilities	State Owned # of Critical Facilities	Total # of State-leased facilities	State-leased Critical Facilities	State-Owned Bridges
Douglas	$914,560	6	6	3	0	49
Dunklin	$37,257,677	30	29	9	1	110
Franklin	$23,749,721	113	51	5	0	133
Gasconade	$3,665,569	17	14	3	0	62
Gentry	$6,959,609	11	9	2	0	51
Greene	$106,533,218	124	100	42	4	194
Grundy	$11,406,129	35	19	5	0	33
Harrison	$2,064,847	14	13	5	2	97
Henry	$4,374,586	18	16	6	0	100
Hickory	$2,069,797	45	9	6	0	29
Holt	$4,259,518	32	10	5	2	93
Howard	$6,948,750	9	9	3	0	50
Howell	$13,010,821	22	21	13	2	123
Iron	$2,701,522	25	10	4	0	80
Jackson	$258,161,011	296	270	49	1	478
Jasper	$38,562,154	144	76	16	1	219
Jefferson	$33,359,735	136	74	13	2	189
Johnson	$37,941,131	110	66	9	0	96
Knox	$731,824	3	3	4	2	48
Laclede	$20,668,332	85	18	9	1	79
Lafayette	$58,594,118	65	38	6	0	92
Lawrence	$36,429,948	40	32	4	0	106
Lewis	$7,842,288	23	6	3	0	53
Lincoln	$12,650,755	137	50	6	1	81
Linn	$4,179,294	48	22	3	0	86
Livingston	$82,771,073	29	22	9	1	64
Macon	$10,316,841	49	19	8	1	93
Madison	$9,225,767	10	9	3	1	68
Maries	$853,648	5	5	2	0	45
Marion	$20,519,792	29	19	6	0	82
McDonald	$3,912,831	21	13	5	0	100
Mercer	$853,648	5	5	4	1	39
Miller	$20,459,482	219	83	7	1	64
Mississippi	$64,553,459	34	17	5	1	61
Moniteau	$47,920,685	44	14	4	0	37
Monroe	$5,334,434	49	18	3	0	63

County	State-Owned Facility and Bridge Replacement Values	Total # of State-Owned Facilities	State Owned # of Critical Facilities	Total # of State-leased facilities	State-leased Critical Facilities	State-Owned Bridges
Montgomery	$6,608,446	33	13	5	0	65
Morgan	$1,036,384	8	8	6	0	52
New Madrid	$12,878,678	34	19	5	1	145
Newton	$17,685,105	31	27	8	1	133
Nodaway	$35,792,033	31	24	7	0	92
Oregon	$1,112,640	15	9	5	1	58
Osage	$6,887,838	8	8	5	0	50
Ozark	$1,768,208	11	11	3	1	46
Pemiscot	$1,767,328	20	20	9	0	134
Perry	$9,244,114	10	9	4	0	52
Pettis	$104,605,409	152	29	8	0	76
Phelps	$47,190,160	45	25	8	0	76
Pike	$86,888,776	43	26	4	2	95
Platte	$10,729,766	53	37	6	0	177
Polk	$7,618,782	20	20	5	0	83
Pulaski	$3,303,349	28	23	8	2	51
Putnam	$792,736	4	4	3	0	42
Ralls	$853,648	5	5	3	0	68
Randolph	$82,308,844	62	29	8	0	54
Ray	$3,492,332	18	17	4	0	74
Reynolds	$1,646,384	9	9	2	0	64
Ripley	$4,408,145	12	12	6	1	70
Saline	$112,328,129	106	51	5	0	83
Schuyler	$731,824	3	3	2	0	45
Scotland	$792,736	4	4	3	0	39
Scott	$27,112,207	42	34	13	1	98
Shannon	$1,097,296	9	9	3	1	41
Shelby	$1,036,384	8	8	3	0	47
St. Charles	$37,813,069	109	97	17	1	181
St. Clair	$1,036,384	8	8	3	0	66
St. Francois	$301,704,674	194	72	10	1	87
St. Louis	$407,256,509	502	386	24	0	466
St. Louis City*	$372,226,727	182	149	42	1	175
Ste. Genevieve	$3,125,380	21	13	6	0	64
Stoddard	$8,960,179	35	26	6	1	183
Stone	$2,316,416	20	20	5	1	36

County	State-Owned Facility and Bridge Replacement Values	Total # of State-Owned Facilities	State Owned # of Critical Facilities	Total # of State-leased facilities	State-leased Critical Facilities	State-Owned Bridges
Sullivan	$1,097,296	9	9	5	1	64
Taney	$11,246,860	56	26	7	2	77
Texas	$73,759,634	43	27	4	0	85
Vernon	$12,130,696	19	18	10	0	113
Warren	$3,587,475	13	12	8	0	56
Washington	$56,800,610	28	23	5	0	94
Wayne	$8,077,037	91	10	4	0	122
Webster	$20,520,485	78	23	5	0	65
Worth	$731,824	3	3	2	0	25
Wright	$2,133,680	17	17	8	2	80
Total	**$475,740,151**	**6044**	**3569**	**959**	**64**	**10,361**

Table 3.7d State-owned Facilities by Department

State Department/sub-department	Total Replacement Cost	# of Facilities	# of Critical Facilities
DED	$15,168,080	8	1
DESE	$142,716,816	2,343	2,343
DESE-SPECIAL EDUCATION	$166,085,309	91	49
DHE	$526,200,574	89	89
DMH	$640,218,540	291	167
DNR	$194,539,093	1,628	280
DOA	$82,605,556	113	3
DOC	$1,436,424,278	629	198
DOLIR	$49,296,995	6	3
DOR	$10,125,530	2	1
DOSS	$77,804,078	137	69
DPS	$634,123,061	448	151
MDC	$142,444,230	688	235
MoDOT (Facilities)	$106,750,000	175	175
MoDOT (Bridges)	$10,417,000,000	10,361	10,361
OA	$693,705,692	84	41
Totals	**$15,335,207,832**	**17,093**	**14,166**

3.7.1 Riverine Flooding

State-owned Facilities in the 100-year Floodplain

To determine which state owned facilities are in the 100-year floodplain, the available GIS data (as documented in the introductory Section 3.7) was compared against the available DFIRM and Hazus generated floodplains. Table 3.7.1a provides the results of the analysis and Table 3.7.1b shows the locations of the facilities.

Table 3.7.1a State-owned Facilities (With GIS Data Provided) in the 100-year Floodplain

Type	Number	Replacement Value
Critical Facilities	82	$59,143,511
Non-critical Facilities	141	$43,211,230
Totals	**223**	**$102,354,742**

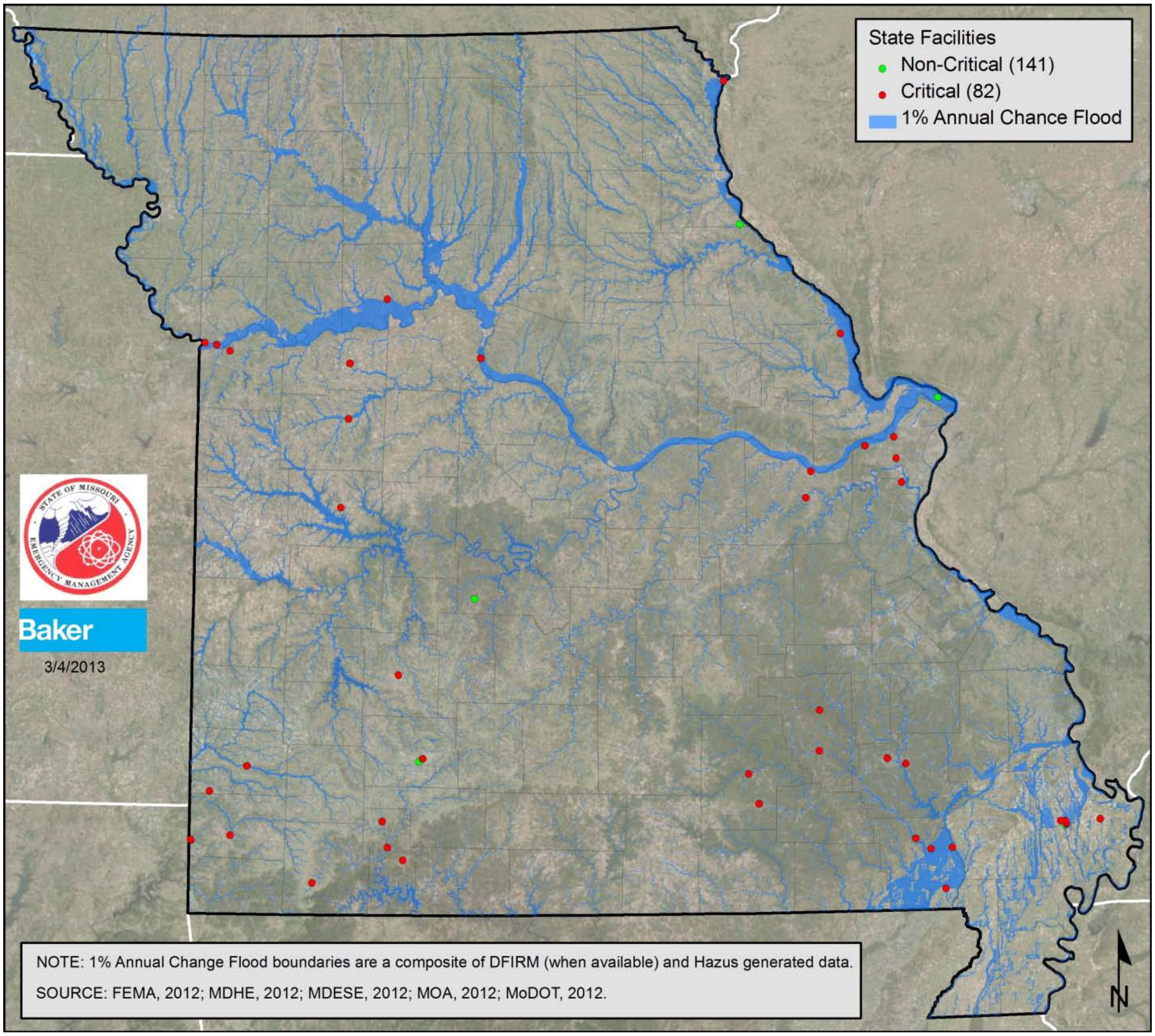
At a conservative loss estimate of 20 percent, damages to state-owned facilities as a result of flood could be $20,470,948. Figure 3.7.1.1 provides the counties with state-owned facilities in the 100-year floodplain based on this analysis. For each county, the total number of state-owned facilities is provided along with the number of critical state-owned facilities and the total replacement cost for all state-owned facilities in the 100-year floodplain.

Table 3.7.1b State-owned Facilities (With GIS Data Provided) in the 100-year Floodplain Reported by County

County	# of State-Owned Facilities	# of Critical State-Owned Facilities	Total Replacement Cost
Barry	1	1	$610,000
Butler	6	4	$2,729,401
Camden	1	0	$26,460
Carroll	1	1	$610,000
Clark	1	1	$60,912
Clay	1	1	$60,912
Franklin	3	2	$1,777,245
Greene	5	2	$11,689,990
Henry	1	1	$610,000
Jackson	3	3	$970,901
Jasper	5	3	$2,810,156
Jefferson	1	1	$60,912
Johnson	2	1	$2,515,284
Lafayette	36	14	$44,341,304
Lincoln	1	1	$610,000
Marion	1	0	$3,199,289
Mississippi	2	1	$6,461,411

County	# of State-Owned Facilities	# of Critical State-Owned Facilities	Total Replacement Cost
New Madrid	1	0	$341,403
Newton	3	3	$182,736
Polk	1	1	$60,912
Reynolds	2	2	$670,912
Saline	28	10	$4,574,144
Scott	4	4	$3,491,372
Shannon	3	3	$182,736
St. Charles	3	0	$233,872
St. Louis	50	16	$8,287,595
Stone	4	4	$243,648
Wayne	53	2	$4,941,227
Total	**223**	**82**	**$102,354,742**

Figure 3.7.1.1 - State-owned Facilities in the 100-year Floodplain

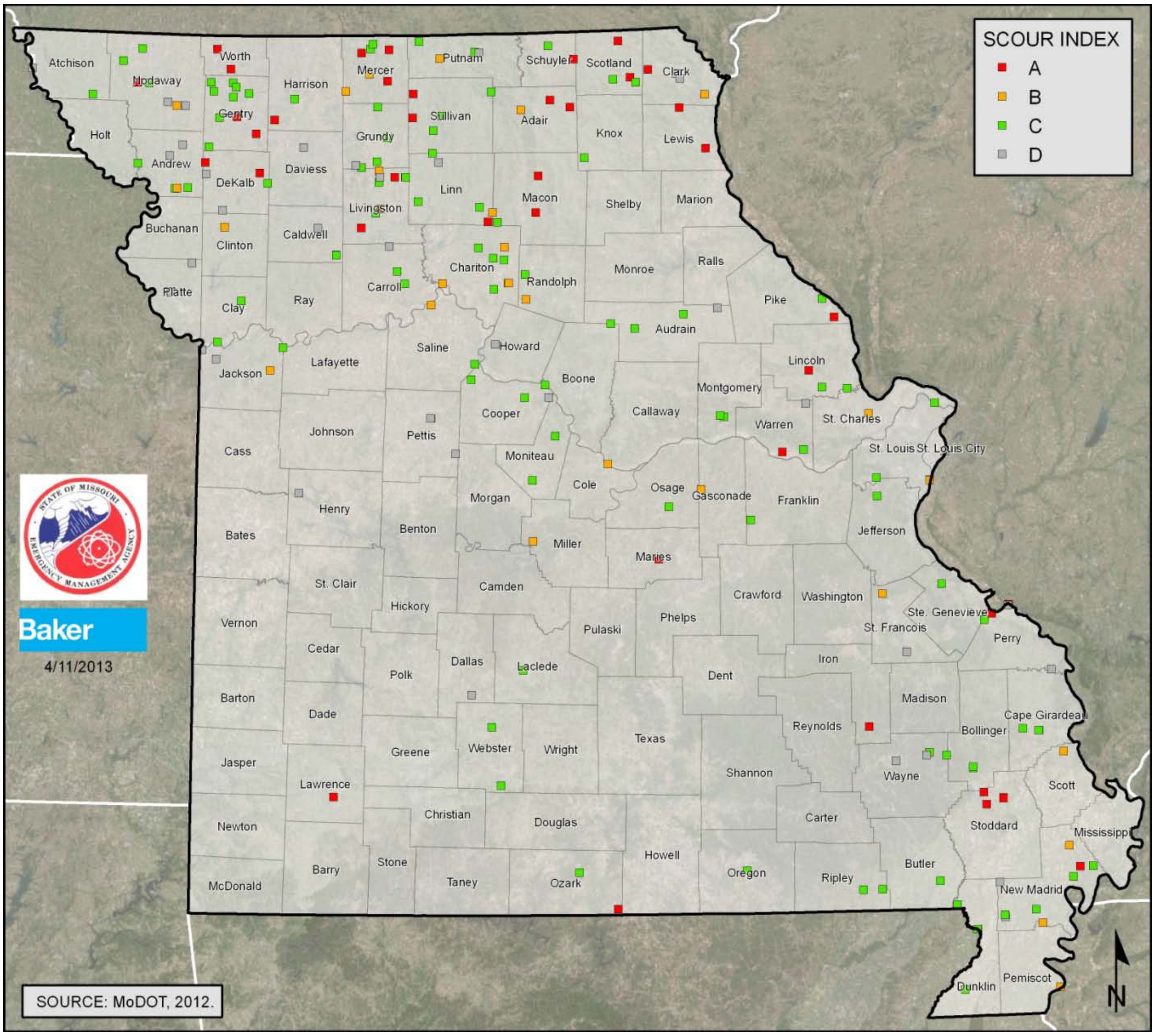


In addition to the analysis of facilities that were available in GIS format, the State analyzed information provided by the Missouri Department of Transportation regarding scour critical state-owned bridges. Scour critical bridges are those bridges that are vulnerable to scour during a flood. Bridge scour is the removal of sediment such as sand and rocks from around bridge abutments or piers. Scour is caused by swiftly moving water and can scoop out scour holes compromising the integrity of the bridge. The Missouri Department of Transportation uses a classification system of A-D to indicate the potential for scour. Those bridges in the "A Class" are those that are most vulnerable to scour and those in the "D Class" are those that are least vulnerable to scour. There are a total of 217 scour critical bridges out of the inventory of 10,361 total state-owned bridges. Table 3.7.1c provides the counts of state-owned bridges in each scour category. Figure 3.7.1.2 provides the locations of these bridges across the State.

Table 3.7.1c Count of State-owned Scour Critical Bridges

Scour Class	# of Bridges	Replacement Cost
A	42	$120,500,000
B	33	$413,000,000
C	100	$248,000,000
D	42	$219,500,000
Totals	**217**	**$1,001,000,000**

Figure 3.7.1.2 - MoDOT State-Owned Flood Scour Critical Bridges



3.7.2 Dam Failure

To determine state-owned facilities that are potentially vulnerable to dam failure, the Missouri Department of Administration, the Department of Higher Education (those available with GIS data), the Department of Transportation and the Department of Natural Resources facilities were identified by their proximity to state-regulated dam inundation areas. A total of 6,986 facilities from the combined departments were identified for analysis. This refined analysis identified 12 total state-owned facilities in known inundation zones of state-regulated Class 1 or Class 2 dams (see Section 3.3.2 for dam classifications). Of the 12 total state-owned facilities within inundation zones, 8 are considered critical facilities. Table 3.7.2a and Table 3.7.2b provide additional details regarding critical facilities and total replacement value, while Figure 3.7.2.1 shows the locations. Replacement values were estimated by each department, however replacement values for leased facilities were not provided for this analysis.

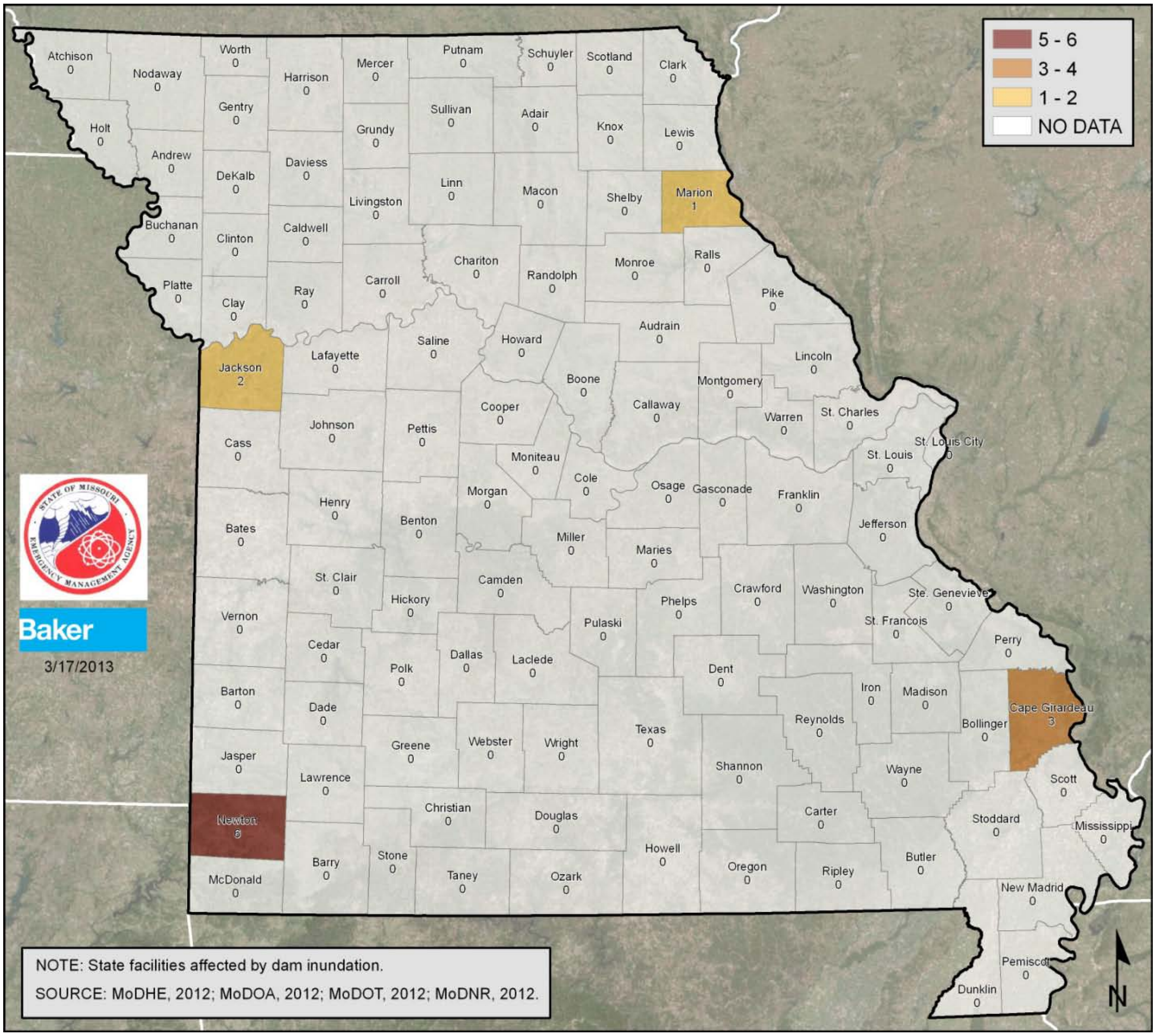
Table 3.7.2a State-owned and Critical Facilities (with GIS data provided) in Inundation Zones of State-regulated Class 1 and 2 Dams

Type	Number	Replacement Value
Critical Facilities	8	$487,296
State-Owned Facilities	4	$3,199,289
Totals	**12**	**$4,173,881**

Table 3.7.2b State-owned Facilities (with GIS data provided) in Inundation Zones of State-regulated Class 1 and 2 dams by County

County	# of State-Owned Facilities	# of Critical State-Owned Facilities	Total Replacement Cost
Cape Girardeau	3	0	Unknown
Jackson	0	2	$121,824
Marion	1	0	$3,199,289
Newton	0	6	$365,472
Total	**4**	**8**	**$4,173,881**

Figure 3.7.2.1 - State-owned Facilities (with GIS data provided) in Potential Inundation Zones of State-regulated Class 1 and 2 dams



3.7.3 Levee Failure

To determine state-owned facilities that are potentially vulnerable to levee failure, the Missouri Department of Administration facilities and education facilities from the Department of Higher Education (those available with GIS data) were identified by their proximity to levee protected areas. As summarized in Table 3.7.3a, a total of 181 facilities from the Office of Administration inventory were found in areas protected from the 1% annual chance flood by levees and are thereby vulnerable to levee failures. Table 3.7.3b provide additional details regarding critical facilities and total replacement costs for each of the 9 counties impacted, and Figure 3.7.3.1 shows the locations of these facilities. It is evident from the map that many facilities within the same county are in close geographic proximity to one another, suggesting that in the event of a catastrophic levee failure, more than one facility could be subject to flooding at once. Figure 3.7.3.2 shows the breakdown of these facilities by category.

Table 3.7.3a State-owned Facilities (with GIS data provided) in Levee Protected Areas

Type	Number	Replacement Value
Critical Facilities	84	$69,092,649
Non-critical Facilities	97	$129,973,200
Totals	**181**	**$199,065,89**

Table 3.7.3b State-owned Facilities (with GIS data provided) in Levee Protected Areas by County

County	# of State-Owned Facilities	# of Critical State-Owned Facilities	Total Replacement Cost
Buchanan	10	3	$17,896,515
Butler	1	1	$60,912
Clark	1	1	$60,912
Clay	3	1	$60,912
Jackson	6	5	$22,995,241
Lewis	2	2	$121,824
Scott	1	1	$610,000
St. Louis	48	14	$7,238,836
St. Louis City	109	56	$150,020,697
Total	**181**	**84**	**$199,065,849**

A precise loss estimate based on depth-damage information for state-owned facilities in potential levee protected areas was not possible due to data limitations. However, by applying a 50 percent damage estimate to the total replacement cost of all 181 facilities determined to be in potential dam inundation zones of state-regulated dams, losses could be $99,532,925.

Figure 3.7.3.1 - State-owned Facilities (with GIS data provided) in Potential Levee Protected Area

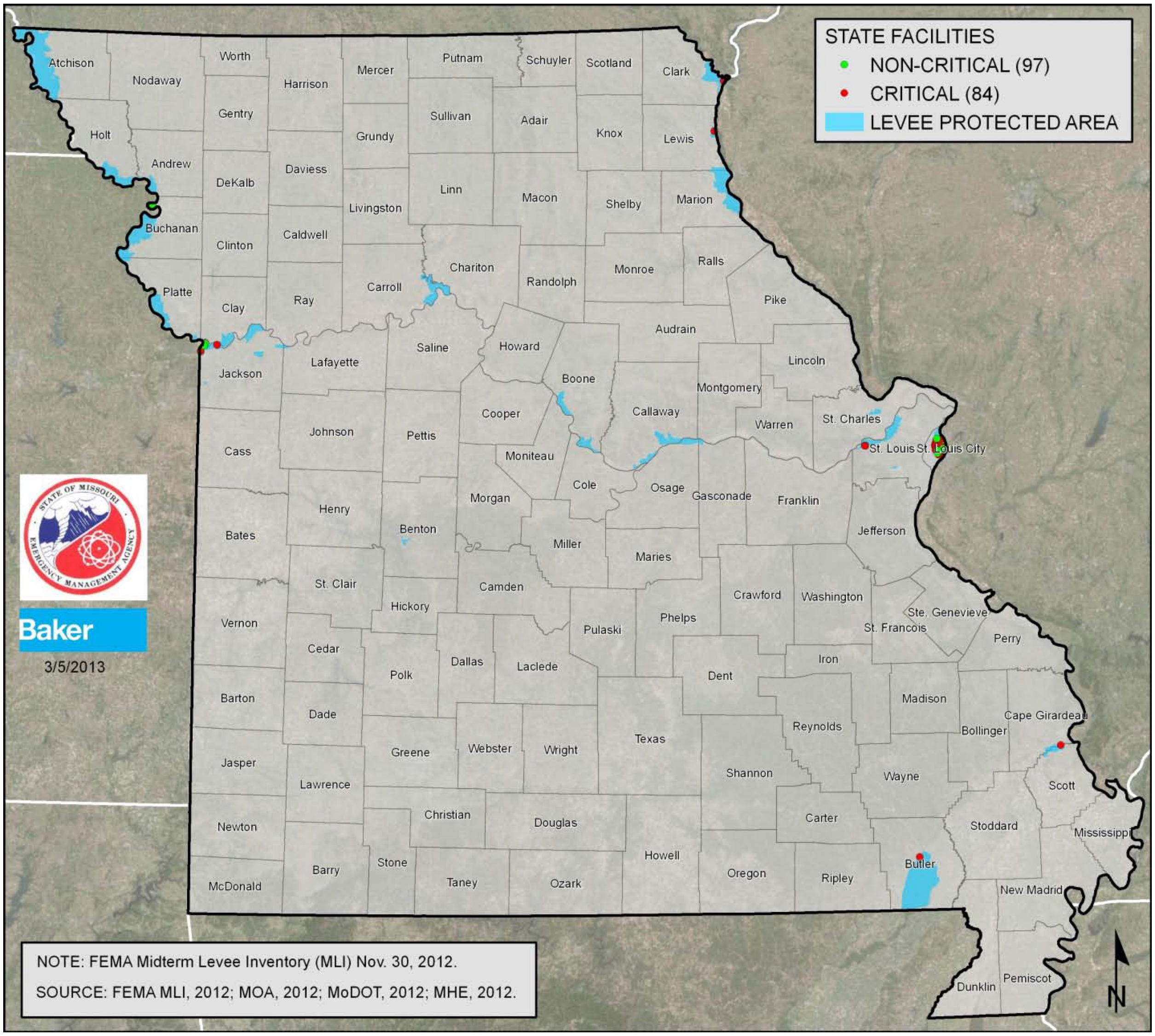
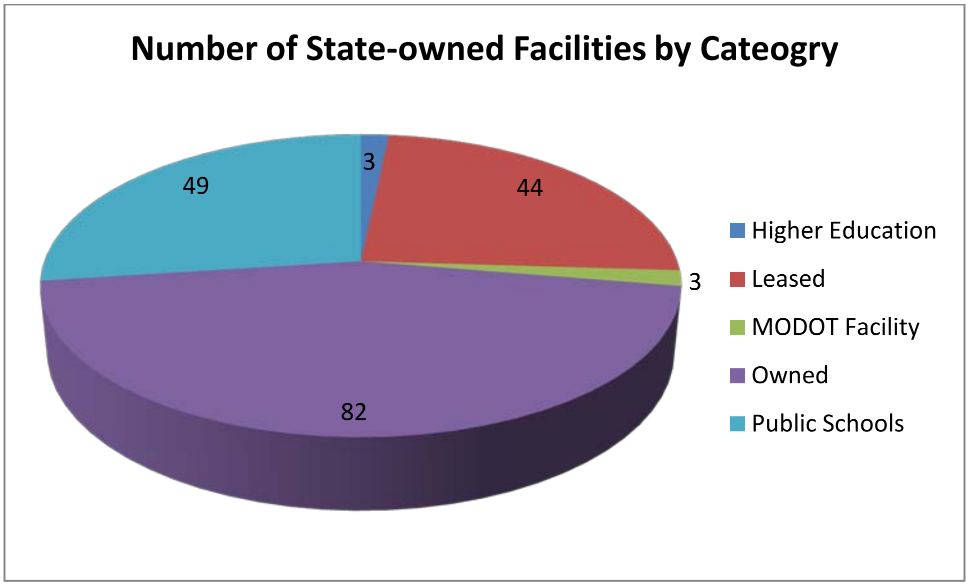


Figure 3.7.3.2 - Number of State-owned facilities by building category in Protected Areas



3.7.4 Earthquakes

Potential for Damage to State-owned Facilities Resulting from Earthquake

This analysis included all facilities and infrastructure with available GIS data as documented in the introductory Section 3.7.0. Based on the resulting Modified Mercalli Intensity and the corresponding Peak-Ground Acceleration (PGA), perceived shaking and potential damage classifications were determined. Table 3.7.4a provides the perceived shaking and potential damage classifications for the Modified Mercalli Intensity and approximate corresponding PGA.

Table 3.7.4a Ground Shaking and Potential Damage Classifications

Modified Mercalli Intensity	Acceleration (%g) (PGA)	Perceived Shaking	Potential Damage
I	<0.17	Not felt	None
II	0.17 – 1.4	Weak	None
III	0.17 – 1.4	Weak	None
IV	1.4 – 3.9	Light	None
V	3.9 – 9.2	Moderate	Very Light
VI	9.2 – 18	Strong	Light
VII	18 – 34	Very Strong	Moderate
VIII	34 – 65	Severe	Moderate to Heavy
IX	65 – 124	Violent	Heavy
X	>124	Extreme	Very Heavy
XI	>124	Extreme	Very Heavy
XII	>124	Extreme	Very Heavy

Facilities

To determine the State owned facilities at risk to earthquake and the corresponding loss estimates, the USGS ground shaking grid with a 2% probability of exceedance in the next 50 years was compared against the locations of State-owned facilities. GIS analysis enabled the potential peak ground acceleration (PGA) (as expressed as % of gravity) with a 2% probability of exceedance in the next 50 years event to be assigned to each facility. Based on the PGA for each state-facility, the perceived shaking and potential damage classifications were applied. To generate potential loss estimates, a percent loss was applied to the potential damage classifications in the following manner: Very Light-10 percent, Light-20 percent, Moderate-30 percent, Moderate to Heavy-40 percent, Heavy-50 percent, and Very Heavy-60 percent. By applying the percent loss to the replacement values of the State-owned facilities, this analysis resulted in an estimated $1,012,098,817 in damages as a result of the earthquake scenario with a 2% probability of exceedance in the next 50 years. It should be noted that only the structure replacement values were considered in this loss estimate as content value was not available. If contents value had been included, the loss estimate would be much higher. Table 3.7.4b provides the summary results of this analysis.

Table 3.7.4b State-owned Facilities and Earthquake Potential Damage Classifications

Potential Damage Classification	Total Facilities	Critical Facilities	Total Replacement Value	Estimated Damage
None	5	1	$23,456	$0
Very Light	2627	1572	$1,637,892,134	$163,789,213
Light	1625	851	$1,626,770,558	$325,354,112
Moderate	1216	825	$1,117,388,196	$335,216,459
Moderate to Heavy	343	148	$196,533,104	$78,621,242
Heavy	104	89	$91,759,047	$45,879,524
Very Heavy	124	84	$105,397,112	$63,238,267
Totals	**6044**	**3570**	**$4,775,763,606**	**$1,012,098,817**

Data Limitation Note: Replacement Value information was not provided for 1.7% of the facilities included in the analysis.

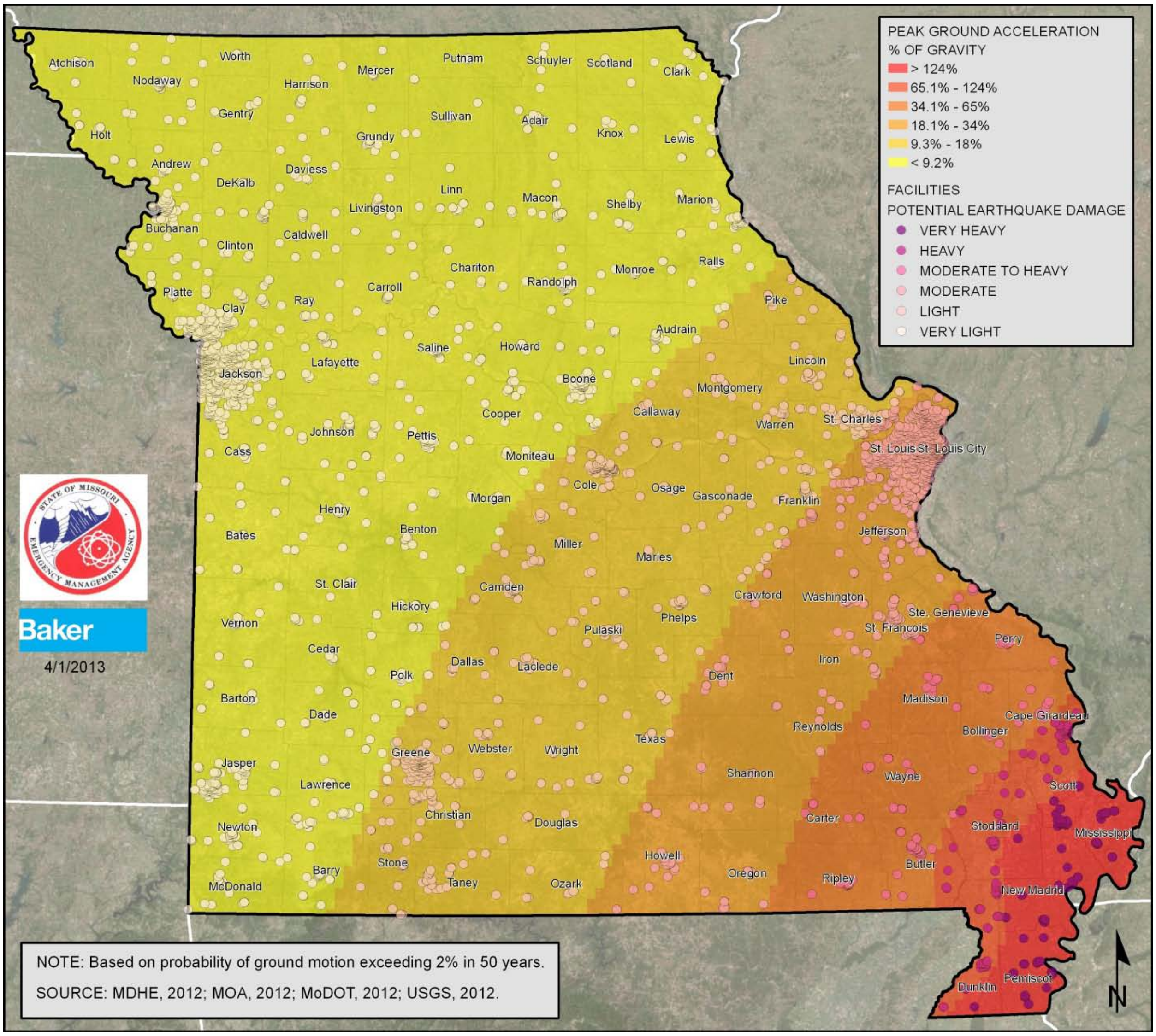
Table 3.7.4c provides a summary of the State-owned facilities in 31 counties that could receive moderate, moderate to heavy, heavy, or very heavy damages. For each county, the total number of state-owned facilities in these categories is provided along with the number of critical state-owned facilities in each category. Figure 3.7.4.1 details the location of these facilities.

Table 3.7.4c State-owned Facilities (with GIS Data Provided) With Resulting Earthquake Potential Damages of Moderate and Higher Reported by County

County	Total Moderate and Higher	Moderate		Moderate to Heavy		Heavy		Very Heavy	
		Total	Critical	Total	Critical	Total	Critical	Total	Critical
Bollinger	11	-	-	11	11	-	-	-	-
Butler	62	-	-	58	40	4	4	-	-
Cape Girardeau	70	-	-	40	14	30	25	-	-
Carter	7	-	-	7	7	-	-	-	-
Crawford	37	37	5	-	-	-	-	-	-
Dent	54	54	14	-	-	-	-	-	-
Dunklin	30	-	-	-	-	29	28	1	1
Franklin	34	34	22	-	-	-	-	-	-
Howell	22	22	21	-	-	-	-	-	-
Iron	25	23	3	2	2	-	-	-	-
Jefferson	136	136	74		-	-	-	-	-
Madison	10	-	-	10	9	-	-	-	-
Mississippi	34	-	-	-	-	-	-	34	17
New Madrid	34	-	-	-	-	-	-	34	19
Oregon	15	15	9	-	-	-	-	-	-
Ozark	2	2	2	-	-	-	-	-	-

County	Total Moderate and Higher	Moderate		Moderate to Heavy		Heavy		Very Heavy	
		Total	Critical	Total	Critical	Total	Critical	Total	Critical
Pemiscot	20	-	-	-	-	-	-	20	20
Perry	10	-	-	10	9	-	-	-	-
Reynolds	9	9	9	-	-	-	-	-	-
Ripley	12	-	-	12	12	-	-	-	-
Scott	42	-	-	-	-	9	9	33	25
Shannon	9	9	9	-	-	-	-	-	-
St. Charles	47	47	40						
St. Francois	194	113	51	81	21	-	-	-	-
St. Louis	501	501	385	-	-	-	-	-	-
St. Louis City	183	183	151	-	-	-	-	-	-
Ste. Genevieve	21	1	1	20	12	-	-	-	-
Stoddard	35	-	-	1	1	32	23	2	2
Texas	2	2	2	-	-	-	-	-	-
Washington	28	28	23	-	-	-	-	-	-
Wayne	91	-	-	91	10	-	-	-	-
Totals	**1787**	**1216**	**821**	**341**	**148**	**104**	**89**	**124**	**84**

Figure 3.7.4.1 - State-owned Facilities with Potential Earthquake Damages Moderate and Above based on Ground Shaking with a 2% Probability of Exceedance in 50 years



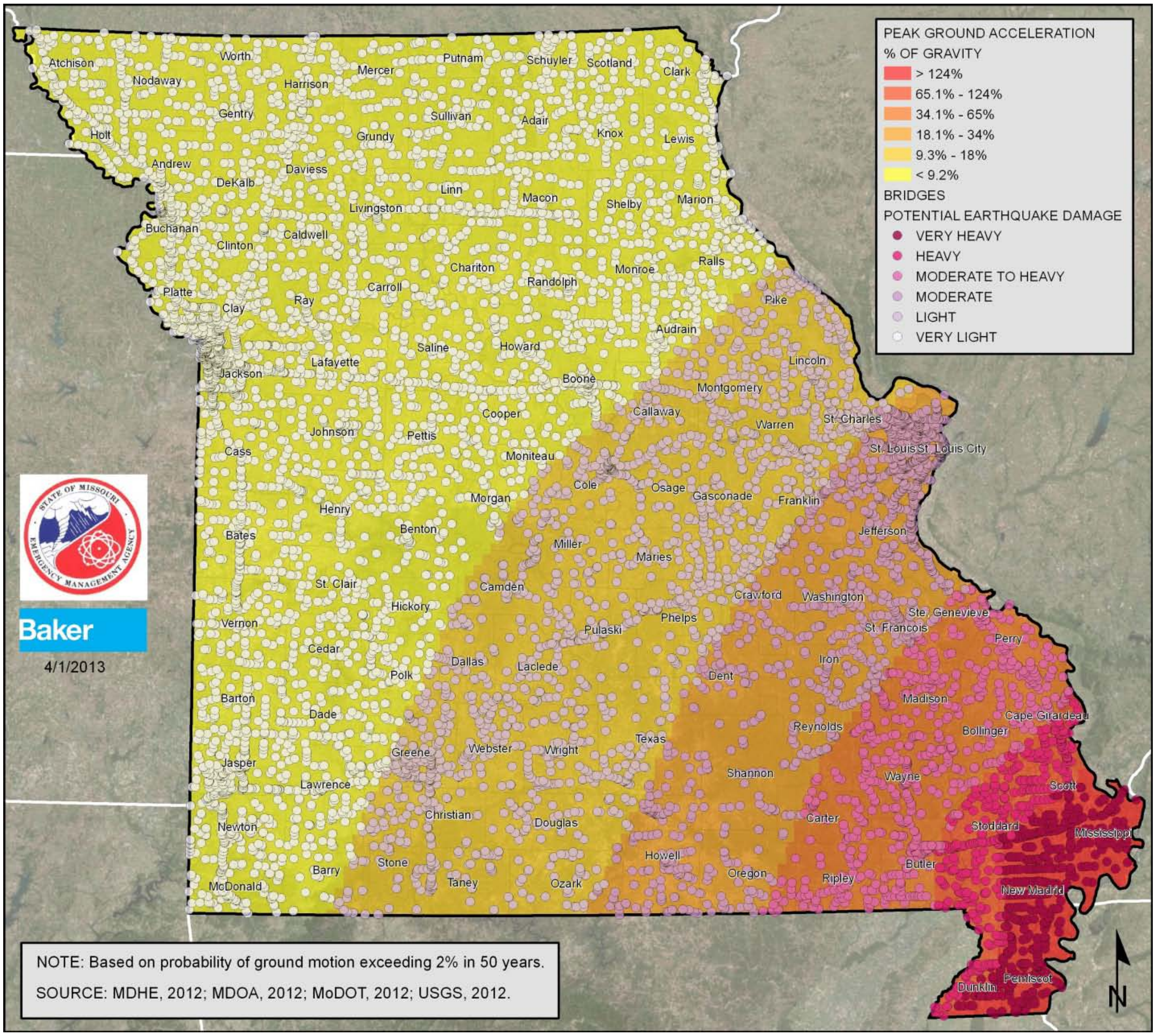
In addition to the analysis of facilities that were available in GIS format, the State analyzed information provided by the Missouri Department of Transportation regarding state-owned bridges. It should be noted that MoDOT considers risk to seismic activity in the design and construction of all new bridges in Missouri. In addition, as older bridges are retrofitted, MoDOT considers incorporation of seismic design standards. This analysis does not differentiate those bridges that have been seismically retrofitted or built to modern design standards.

Table 3.7.4d provides the counts of state-owned bridges by PGA range according to the seismic event with a 2% probability of exceedance in 50 years. Figure 3.7.4.2 provides the locations of the bridges in critical counties with sorted in PGA Ranges.

Table 3.7.4d Counts of State-owned Bridges by PGA Range

PGA	# of Bridges	Replacement Cost
<1.4	-	
1.4-3.9	19	$9,500,000
3.9-9.2	5319	$6,089,500,000
9.2-18	1993	$2,129,000,000
18-34	1614	$2,295,000,000
34-65	696	$447,500,000
65-124	384	$316,000,000
>124	466	$531,500,000
Totals	**10491**	**$11,818,000,000**

Figure 3.7.4.2 - MoDOT State-Owned Bridges by PGA Range based on Ground Shaking with a 2% Probability of Exceedance in 50 years



3.7.5 Land Subsidence/Sinkholes

The following Missouri Counties in Table 3.7.5a have more than 400 known sinkholes (see Section 3.5.5). At this time, sufficient GIS data is not available locating all sinkholes to determine proximity of State-owned facilities.

Table 3.7.5a State-owned Facilities in Counties with High Vulnerability to Sinkholes

County	Replacement Value	Total State-owned Facilities	Critical State-owned Facilities	Total # of State-leased facilities	State-leased Critical Facilities	Total Annual Rent
Boone	$38,122,775	30	6	18	1	$1,339,141
Cape Girardeau	$49,046,578	43	12	29	2	$1,650,523
Christian	$2,498,272	0	0	6	0	$136,856
Dent	$8,555,404	43	3	5	1	$102,775
Greene	$106,533,218	29	5	42	4	$2,074,769
Howell	$$130,010,821	4	3	13	2	$329,657
Oregon	$1,112,640	6	0	5	1	$35,157
Perry	$9,244,114	2	1	3	0	$61,108
Shannon	$1,097,296	0	0	3	1	$41,181
St. Louis	$407,195,597	219	103	22	0	$1,517,083
Ste. Genevieve	$3,125,380	16	8	6	0	$25,637
Texas	$73,759,634	27	11	4	0	$106,349

Due to the nature of the hazard, predicting future occurrences can be very difficult. Identifying void spaces left by mining operations can be used to help predict future sites of land subsidence. In addition, this hazard generally occurs over a period of time, allowing time for a response to be formulated. The Missouri Department of Natural Resources has a web page dedicated to sinkholes.[70] This website provides tools that allow the user to create maps of known sinkholes and locations from the State Mine Map Repository. In addition, there are brochures available on the site for dealing with sinkholes, and potential mitigation against them.

70 http://www.dnr.mo.gov/geology/geosrv/envgeo/sinkholes.htm

3.7.6 Severe Thunderstorms (includes damaging winds, hail and lightning)

A research investigation was conducted to determine which counties had the most vulnerable to severe thunderstorms including damaging winds, hail, and lightning state owned and leased facilities. Severe thunderstorms including damaging winds, hail, and lightning are a dangerous threat to state owned facilities around Missouri. As a part of this analysis, state owned and leased facilities were ranked according to their vulnerability to Severe Thunderstorms. Table 3.7.6a below shows the counties where those facilities reside that ranked either high or medium-high in terms of their vulnerability. For additional information on the rating system see Section 3.5.6. The table also provides the total number of state owned and leased facilities in each county, the number of facilities determined to be critical, and the total replacement value of those facilities.

Table 3.7.6a State-owned and Leased Facilities in Counties with High and Medium-High Vulnerability to Severe Thunderstorms

County	Replacement Value	Total State-owned Facilities	Critical State-owned Facilities	Total # of State-leased facilities	State-leased Critical Facilities	
Jackson	$258,161,010	296	270	52	1	
Jasper	$38,501,242	143	75	15	1	
St. Charles	$37,813,060	109	97	18	1	
St. Louis	$407,195,597	501	385	22	0	

3.7.7 Tornadoes

The counties in Table 3.7.7a below are those counties that received a Very High vulnerability rating for Tornadoes (See Section 3.5.7). The table provides the total number of state-owned facilities in these counties as well as the number of facilities determined to be critical and the total replacement value. Information is also provided for the number of state-leased facilities in these counties, the number of leased facilities determined to be critical and the total annual rent.

Table 3.7.7a State-owned and Leased Facilities in Counties with Very High Vulnerability to Tornadoes

County	Replacement Value	Total State-owned Facilities	Critical State-owned Facilities	Total # of State-leased facilities	State-leased Critical Facilities
Boone	$38,122,776	87	64	18	17
Cass	$13,286,085	53	50	4	0
Christian	$2,498,272	32	32	6	0
Greene	$106,533,218	124	100	42	4
Newton	$17,746,017	32	28	10	2
Ozark	$1,768,208	11	11	3	1
Pemiscot	$1,767,328	20	20	8	0
Platte	$10,729,766	53	37	5	5
Scott	$27,112,207	42	34	13	1
St. Charles	$37,813,069	109	97	18	1
Taney	$11,246,861	56	26	7	2
Warren	$3,587,475	13	12	8	0
Worth	$731,824	5	3	2	0

These Counties are distributed across the State. While some of the counties are located in close proximity to each other, they are found in the western, eastern and southern parts of the state. This illustrates the fact that the entire state is vulnerable to tornadoes. These eleven counties have been determined to be the most vulnerable to tornadoes within Missouri. There are over 900 state-owned facilities in these counties, of which over 600 are deemed to be critical. The replacement value of these buildings is in excess of $300 million. In addition, there are 148 leased facilities in these counties, with 29 of those deemed to be critical.

3.7.8 Severe Winter Weather/Snow/Ice/Severe Cold

A research investigation was conducted to determine which counties had the most vulnerable to severe winter weather, snow, ice, and severe cold state owned and leased facilities. Severe winter weather includes nor'easters and other snow and ice events that have the potential to cause serious damage to state facilities. As part of this analysis, state owned and leased facilities were ranked according to their vulnerability to severe winter weather, snow, ice, and severe cold. Table 3.7.8a below shows the counties where facilities reside that ranked either high or medium-high in terms of their vulnerability. For additional information on the rating system see Section 3.5.8. The table below also provides the total replacement value of those facilities.

Table 3.7.8a State-owned and Leased Facilities in Counties with High Vulnerability to Severe Winter Weather

County	Replacement Value	Total State-owned Facilities	Critical State-owned Facilities	Total # of State-leased facilities	State-leased Critical Facilities
Atchison	$975,472	7	7	5	1
Bates	$3,278,428	20	15	5	0
Butler	$38,387,955	62	44	1	1
Carroll	$1,401,856	14	14	4	0
Carter	$1,524,560	7	7	5	1
Chariton	$1,097,296	9	9	3	0
Clark	$2,749,861	28	15	4	1
Cooper	$50,329,756	60	35	6	0
Dade	$4,251,964	44	11	4	0
Daviess	$1,219,120	11	11	5	2
DeKalb	$9,051,563	12	10	11	0
Dunklin	$37,257,677	30	29	9	1
Gentry	$6,959,609	11	9	2	0
Grundy	$11,406,129	35	19	5	0
Harrison	$2,064,847	14	13	5	2
Henry	$4,374,586	18	16	6	0
Holt	$4,259,518	32	10	5	2
Jackson	$258,161,011	296	270	52	1
Knox	$731,824	3	3	4	2
Lafayette	$58,594,118	65	38	7	0
Mercer	$853,648	5	5	4	1
Mississippi	$64,553,459	34	17	5	1
New Madrid	$12,878,678	34	19	6	1
Nodaway	$35,792,033	31	24	7	0
Pemiscot	$1,767,328	20	20	8	0

County	Replacement Value	Total State-owned Facilities	Critical State-owned Facilities	Total # of State-leased facilities	State-leased Critical Facilities
Pettis	$104,605,409	152	29	8	0
Putnam	$792,736	4	4	3	0
Saline	$112,328,129	106	51	5	0
Schuyler	$731,824	3	3	2	0
Scotland	$792,736	4	4	3	0
Scott	$27,112,207	42	34	13	1
Shelby	$1,036,384	8	8	3	0
St. Louis	$407,195,597	501	385	22	0
Stoddard	$8,960,179	35	26	6	1
Sullivan	$1,097,296	9	9	5	1
Vernon	$12,130,696	19	18	10	0
Worth	$731,824	3	3	2	0

3.7.9 Drought

Data is not available to quantify vulnerability or estimate losses as a result of drought on State owned facilities. A research investigation was conducted to determine if there was additional non-quantifiable data that could add information or provide a better understanding of the vulnerability of facilities. This information is provided for review purposes only and has not been incorporated into the mitigation analysis however any information of significance has been included below.

Drought has had a significant impact on the State of Missouri and the State has taken an active role in addresses the issue. The Governor, Jay Nixon, took an active role in 2012 in addressing drought conditions and supporting programs that improved conditions for crop and livestock production[71]. The State of Missouri Drought Plan from 2002 provides information on the State's drought response plan[72]. Designed to work in conjunction with the State Consolidated Plan and the State Emergency Operations Plan, the Drought Plan looks at the strategic and tactical measures designed to better prepare Missouri for drought.

The State Department of Natural Resources has a website devoted to addressing drought issue and water management which provides current information on conditions in the State[73]. While not quantifiably vulnerable to drought alone, structures of all kinds are vulnerable to the shrink-swell cycle that occurs as soils swell during wet periods and shrink during dry periods. Of particular concern are MoDOT roads and bridges. Concrete structures like these are not able to expand and contract with the movement of soil and can be damaged or broken as a result.

Most of the impacts associated with drought are to crop land, not facilities however there are conservation areas owned and operated by the Missouri Department of Conservation that may be impacted by drought. Many of these are in recreational areas, areas such as are streams, lakes, reservoirs, and ponds that can shrink in size or completely dry up causing the death of fish and other wildlife as well as a potential loss of recreation-based revenue and negatively impact municipal water supply.

71 http://governor.mo.gov/newsroom/2012/gov_nixon_announces_emergency_program_dig_deepen_wells_mexico
72 http://www.dnr.mo.gov/pubs/WR69.pdf Missouri Drought Plan
73 http://www.dnr.mo.gov/env/wrc/droughtupdate.htm

3.7.10 Extreme Temperature

Figure 3.7.10.1 - Roadway in rural Missouri

Source: Photo by jaxbot on flckr.com, December 11, 2012

The hazard of extreme temperature does not directly impact state-owned building facilities. However, asphalt parking lots and roads are routinely damaged during periods of extreme heat as the hot asphalt becomes less rigid and can be displaced by heavy equipment or automobiles. As a result of the major heat wave of 1980, hundreds of miles of highway buckled in the mid-west and south central regions of the country (Weatherwise, 1981). Train rails can also deform during extreme hot weather, causing vulnerability in transportation lines (Adams, 1997). In fact, multiple train derailments around the nation were attributed to the heat wave that struck the U.S. in July, 2012[74].

In addition to heat malformations, heat waves can overtax building cooling systems and power grids. This can affect operating costs for State owned buildings as well as require the State to employ additional manpower to handle the increase in need. This is especially true for state agencies that cater to at risk communities such as the elderly and the homeless as those populations often require the most additional care during a temperature related event[75].

[74] http://www.nytimes.com/2012/07/08/us/temperatures-soar-as-heat-wave-continues.html?_r=0
[75] http://www.epa.gov/climatechange/impacts-adaptation/health.html

Extreme cold can challenge building heating systems. Homes without adequate heat or insulation often lead inhabitants to use space heaters or fireplaces to stay warm, increasing the risk of carbon monoxide poisoning and structure fires. If pipes are exposed to cold temperatures, they may freeze and burst (CDC, 2013). Similarly to bouts of extreme heat, the drain on resources caused by an increased power load can affect the state's energy grid as people without access to alternative heat sources rely on electricity to keep them warm.

During bouts of extreme cold, the homeless and indigent populations of the state are at an especially increased risk. Many nonprofit community groups like the Salvation Army will open their doors in an attempt to shelter those in need during such times when the temperature drops become dangerous, however they are unable to shelter everyone[76]. With a homeless population of more than 7000 persons in 2010, far too often people are left to freeze to death in the cold each winter[77].

[76] http://www.knowledgeplex.org/news/2902331.html
[77] http://www.mhdc.com/ci/documents/SHM_2011.pdf

3.7.11 Fires (Urban/Structural and Wild)

Fires can range in scope to include structural, urban, and wild fires. For the purpose of this analysis, structural and urban fires are considered in one category, with wild fires, including forest, prairie, and grassland locations, considered separately. [78]

Structural fires are a major problem that can affect any area of the state. The Missouri Division of Fire Safety (MDFS) indicates that approximately 90% of the fire departments in Missouri are staffed with volunteers dedicated to the task of fire prevention and suppression. Whether paid or volunteer, departments are often limited by lack of resources and financial assistance. The impact of a fire to a single – story building in a small community may be as great as that of a larger fire to a multi – story building in a large city.[79]

While many of these fires may be accidental, some of them are caused by arson. According to the MDFS, Arson is the most costly crime in the State. It affects citizens through insurance premiums, lost jobs, loss of lives, injuries, and property losses.[80]

In addition to urban and structural fires, wild fires can occur at any time of the year and have considerable effects around the state. The Forestry Division of the Missouri Department of Conservation is responsible for protecting privately owned and state owned facilities. Despite the efforts of this department, each year, an average of 2,800 wildfires burn more than 43,300 acres of forest and grassland. This is especially dangers as Table 3.146 illustrates due to the fact that there are a number of state owned facilities located within forests and grasslands that may rapidly turn into a wildfire if conditions permit[81]. Table 3.146 also shows the number of facilities determined to be critical and the total replacement value for each County within the State. Additionally, it provides the number of state-leased facilities in each county and the number of leased facilities determined to critical.

In Table 3.7.11a (shown on next page) the total number of state-owned facilities is listed as well as the number of facilities determined to be critical and the total replacement value for each county. Information is also provided for the number of state-leased facilities in these counties, the number of leased facilities determined to be critical.

[78] http://sema.dps.mo.gov/docs/programs/Planning,%20Disaster%20&%20Recovery/State%20of%20Missouri%20Hazard%20Analysis/2012-State-Hazard-Analysis/Annex_I_Fires.pdf
[79] http://sema.dps.mo.gov/docs/programs/Planning,%20Disaster%20&%20Recovery/State%20of%20Missouri%20Hazard%20Analysis/2012-State-Hazard-Analysis/Annex_I_Fires.pdf
[80] http://sema.dps.mo.gov/docs/programs/Planning,%20Disaster%20&%20Recovery/State%20of%20Missouri%20Hazard%20Analysis/2012-State-Hazard-Analysis/Annex_I_Fires.pdf
[81] http://sema.dps.mo.gov/docs/programs/Planning,%20Disaster%20&%20Recovery/State%20of%20Missouri%20Hazard%20Analysis/2012-State-Hazard-Analysis/Annex_I_Fires.pdf

Table 3.7.11a State-owned Facilities in Forest and Grassland Areas by County

County	Replacement Value	Total State-owned Facilities	Critical State-owned Facilities	Total # of State-leased facilities	State-leased Critical Facilities
Adair	$41,676,525	9	3	11	3
Andrew	$3,230,976	0	0	1	0
Atchison	$2,500,032	0	0	9	2
Audrain	$32,980,266	6	3	9	3
Barry	$4,473,205	5	0	9	2
Barton	$4,252,919	6	0	5	0
Bates	$8,285,282	3	0	3	0
Benton	$6,404,862	4	0	10	3
Bollinger	$3,840,976	0	0	2	0
Boone	$50,204,384	13	3	7	2
Buchanan	$148,113,650	18	5	4	2
Butler	$35,546,918	20	8	7	3
Caldwell	$3,047,360	0	0	7	0
Callaway	$67,742,591	9	0	8	0
Camden	$7,616,511	13	0	25	7
Cape Girardeau	$40,408,521	13	0	25	3
Carroll	$3,413,712	0	0	5	0
Carter	$4,390,944	0	0	4	0
Cass	$21,651,954	3	0	4	0
Cedar	$4,634,592	0	0	12	0
Chariton	$2,926,416	0	0	3	0
Christian	$6,520,224	0	0	5	0
Clark	$3,594,944	3	0	2	0
Clay	$39,648,075	7	0	10	2
Clinton	$3,173,443	5	0	8	0
Cole	$234,255,523	48	15	89	0
Cooper	$20,765,621	6	2	5	0
Crawford	$8,383,150	7	0	10	3
Dade	$3,583,026	6	0	6	0
Dallas	$1,950,064	0	0	5	0
Daviess	$3,352,800	0	0	8	3
DeKalb	$11,429,771	2	0	9	0
Dent	$5,672,609	3	0	3	0
Douglas	$3,231,856	0	0	4	0
Dunklin	$55,603,895	2	1	7	2

County	Replacement Value	Total State-owned Facilities	Critical State-owned Facilities	Total # of State-leased facilities	State-leased Critical Facilities
Franklin	$39,079,502	17	0	8	0
Gasconade	$4,156,399	4	0	4	0
Gentry	$3,437,550	3	0	6	0
Greene	$121,050,456	24	0	38	6
Grundy	$2,578,295	2	0	3	0
Harrison	$5,646,332	3	0	6	3
Henry	$3,695,680	1	0	4	0
Hickory	$2,701,917	8	0	7	0
Holt	$2,132,091	2	0	6	3
Howard	$13,897,500	0	0	4	0
Howell	$15,539,234	4	1	11	5
Iron	$5,260,868	6	0	6	0
Jackson	$292,357,826	44	24	36	1
Jasper	$34,038,479	18	3	13	2
Jefferson	$51,751,048	17	4	21	5
Johnson	$20,239,433	9	0	7	0
Knox	$1,524,560	0	0	6	3
Laclede	$10,370,172	8	0	9	1
Lafayette	$44,004,935	12	6	9	0
Lawrence	$13,653,888	10	0	6	0
Lewis	$20,777,996	6	0	3	0
Lincoln	$6,053,836	3	0	7	0
Linn	$4,053,469	6	0	4	0
Livingston	$20,424,998	5	1	10	3
Macon	$5,272,071	8	0	3	0
Madison	$34,211,511	7	3	11	4
Maries	$2,378,208	0	0	3	0
Marion	$42,738,635	14	0	8	0
McDonald	$3,847,391	7	0	3	0
Mercer	$2,378,208	0	0	7	1
Miller	$6,623,506	6	0	5	1
Mississippi	$10,933,811	3	0	6	2
Moniteau	$14,646,931	3	0	4	0
Monroe	$3,130,820	6	0	4	0
Montgomery	$1,592,819	3	0	9	0
Morgan	$2,926,416	0	0	7	0

County	Replacement Value	Total State-owned Facilities	Critical State-owned Facilities	Total # of State-leased facilities	State-leased Critical Facilities
New Madrid	$20,580,169	8	0	3	0
Newton	$22,633,982	7	3	17	3
Nodaway	$54,434,967	4	3	3	0
Oregon	$3,109,152	4	0	7	0
Osage	$20,480,778	0	0	7	0
Ozark	$151,735	0	0	8	4
Pemiscot	$2,132,800	0	0	7	0
Perry	$13,726,608	1	0	1	0
Pettis	$18,124,610	5	1	6	0
Phelps	$17,578,599	14	0	3	0
Pike	$23,570,945	5	3	2	0
Platte	$20,924,575	3	0	7	0
Polk	$16,213,036	0	0	12	0
Pulaski	$8,413,056	10	0	14	7
Putnam	$1,463,648	0	0	4	0
Ralls	$2,256,384	0	0	8	0
Randolph	$27,941,894	10	0	8	0
Ray	$4,463,310	3	0	3	0
Reynolds	$5,731,888	0	0	4	0
Ripley	$3,555,289	2	2	4	0
Saline	$53,605,943	11	2	2	0
Schuyler	$2,012,736	0	0	3	0
Scotland	$2,378,208	0	0	3	0
Scott	$35,314,593	6	4	4	2
Shannon	$4,084,624	0	0	4	0
Shelby	$1,219,120	0	0	5	0
St. Charles	$46,494,019	11	0	24	2
St. Clair	$3,292,768	0	0	7	0
St. Francois	$50,926,637	21	1	9	0
St. Louis	$345,442,265	48	7	26	0
St. Louis City*	$280,016,847	20	5	9	1
Ste. Genevieve	$6,283,766	6	0	9	0
Stoddard	$7,874,347	5	0	4	1
Stone	$7,315,600	0	0	14	4
Sullivan	$2,804,592	0	0	5	0
Taney	$33,160,932	8	0	5	0

County	Replacement Value	Total State-owned Facilities	Critical State-owned Facilities	Total # of State-leased facilities	State-leased Critical Facilities
Texas	$20,285,712	11	0	3	0
Vernon	$9,504,527	3	0	11	0
Warren	$3,882,828	3	0	13	0
Washington	$55,736,831	10	7	6	0
Wayne	$7,580,419	10	0	7	0
Webster	$6,377,989	2	0	11	0
Worth	$2,012,736	0	0	2	0
Wright	$6,218,304	0	0	9	0

3.7.12 Attack (Nuclear, Conventional Chemical, and Biological)

Data is not available to quantify vulnerability or estimated losses as a result of attack incidents that might impact state-owned facilities. In addition, a research investigation was conducted to determine if there was additional non-quantifiable data that could add information or provide a better understanding of vulnerability of facilities. This information is provided for review purposes only and has not been incorporated into the mitigation analysis. The information determined to be of significance is provided below.

The State of Missouri Hazard Analysis, December 2012, Annex O: Attack (Chemical, Biological, Radiological, Nuclear and Explosive)[82] provides background information on the description of potential hazards, historical data (world-wide), probability and impacts of various types of attacks. The information is generalized to the United States and does not apply specifically to Missouri or areas within the State.

Nuclear, chemical and biological materials are used for many lawful purposes throughout the state of Missouri. While these materials can be used improperly for unlawful acts, based on the state hazard analysis, the probability of these activities taking place is low.

Nuclear
Nuclear materials are used throughout the state. Along with industrial locations and facilities such as hospitals, there are specific locations where nuclear materials are used. Locations such as the Honeywell Nuclear Bomb Parts Factory in Kansas City, the Boeing Defense, Space and Security Plant near St. Louis, and Whiteman Air Force Base near Knob Noster are locations where nuclear materials and related equipment are manufactured, stored and utilized. These locations could be seen as sources of these materials by unlawful persons.

The Callaway Nuclear Generating Station, located near Fulton, Missouri, is located in Callaway County. The plant is the only nuclear generating facility in the state and has been in operation since 1984. The plant has established emergency management plans and protocols in place.

Chemical
There are thousands of sources of chemicals throughout the state, and while these materials are used daily, some can be used for unlawful activities. Some chemicals which are safe during normal use can become dangerous when used or handled improperly. Probability of a chemical incident is low, but is likely higher than biological attacks and much higher than a nuclear attack due to the wide distribution and ease of access to many chemicals.

Biological
A biological attack can come in many forms, from a release of a weaponized material which is instantly obvious, to a secret release which is not immediately known. Agents can be materials that are purposefully created to cause harm, or regular agents used for commercial purposes but are used improperly to cause harm. It could also come from a purposeful incident of food adulteration and which might only be detected as public health reporting identifies an emerging pattern of unusual illness. In

[82] http://sema.dps.mo.gov/docs/programs/Planning,%20Disaster%20&%20Recovery/State%20of%20Missouri%20Hazard%20Analysis/2012-State-Hazard-Analysis/Annex_O_Attack.pdf

addition to harming humans, biological incidents can be targeted to agriculture, with impacts that affect livestock and food crops and disrupt the food supply chain. The state hazard analysis has ranked the probability of such an action as low.

3.7.13 Civil Disorder

Civil disorder is generally used to define groups of people who actively chose to not follow laws, rules or regulations. Civil Disorder can occur in many different ways, from organized efforts to bring attention to causes, with people having a common agenda, to unorganized, spontaneous incidents where a "mob" mentality drives people to act in a similar way. Civil disorder can involve small or large groups, and in many cases, these groups use their presence to limit, block, or halt other common activities, such as closing streets to traffic, or protesting at a defined location.

Overall civil disorder in the State of Missouri is rare, with few occurrences in the last few decades. While in the past incidents focused on protests around the civil rights movement, the anti-Vietnam War movement and in smaller cases the anti-abortion movement have caused incidents, public events of civil disorder are less common than in prior decades. Recent State rulings have banned protests in or around funeral processions and locations.

Civil disorder can occur at random times and locations if occurring based on real-time events under a mob-like scenario. While some civil disorders (protests) are planned ahead and governmental permission is granted, a more common scenario is of an event that is unknown to government and is unknown until the incident begins. As a result, it is difficult to specify state-owned or operated facilities that may be impacted by this hazard. As indicated in Section 3.5.13, incarcerated populations can be more prone to civil disorder as a concentrated group of high-risk individuals. Therefore, the State-owned correctional facilities with incarcerated populations could be considered to be at higher risk to civil disorder than other state-owned facilities. There are 189 state-owned facilities that were identified as areas where groups of incarcerated individuals are located at times. There were no state-leased facilities with incarcerated populations at the site. The state-owned facilities with incarcerated populations are located in the following Missouri counties in 3.7.13a.

Table 3.7.13a State-owned Facilities with Incarcerated Populations

County	# of Facilities w/ Incarcerated Persons
Audrain	6
Buchanan	4
Callaway	12
Cole	34
Cooper	13
DeKalb	19
Dunklin	1
Livingston	6
Marion	1
Mississippi	9
Moniteau	14
Nodaway	1
Pike	11

County	# of Facilities w/ Incarcerated Persons
Randolph	5
St. Francois	30
St. Louis	6
Texas	9
Washington	6
Webster	6
Total	182

In addition to correctional facilities, educational facilities may have a higher possible rate of civil disorder than other locations as students are more likely to express opinions openly in an academic environment. Many institutions in the State have plans and programs in place to manage civil disorder if such an event were to occur. These facilities have plans in place to work with local jurisdictions to manage events.

3.7.14 Cyber Disruptions

Data is not available to quantify vulnerability or estimated losses as a result of terrorism incidents that might impact state-owned facilities. Data is not available to quantify vulnerability or estimated losses as a result of terrorism incidents that might impact state-owned facilities. A research investigation was conducted to determine if there was additional non-quantifiable data that could add information or provide a better understanding of vulnerability of facilities. This information is provided for review purposes only and has not been incorporated into the mitigation analysis. The information determined to be of significance is provided below.

There are many types of cyber disruptions producing a wide variety of societal impacts. Incidents can range from purposeful criminal activities meant to steal money or information, to making public statements (defacto internet protests), to purposefully causing infrastructure damage or injuring persons through disruptions. The most severe cyber-disruption is defined as Cyberterrorism - a terrorist act designed to cause disruptions to computer-based information systems with the express purpose to cause fear, injury or economic loss. In addition to these disruptions, some government entities and businesses are susceptible to cyber activities with some becoming ongoing targets of "hackers" looking to cause harm or promote a personal or political agenda. In many cases, nationally, there are individuals and groups whose mission is to purposefully disrupt and hack systems to cause disruptions and damage.

The most common type of attack cyber criminal's use is the direct denial of service or DDoS attack. This is where a server or website will be pinged rapidly with information requests overloading the system and causing it to crash. DDoS attacks have been a commonly used tool of organizations labeled by the FBI as cyber terrorists such as Anonymous and Lulz Security. Additionally, these organizations have organized website defacements largely as protests against perceived injustices and/or groups they consider hate groups.

More sinister attacks have been carried out by other cyber terrorist groups. For example, Russian and Ukrainian hackers attacked a public hospital and stole a more than $1 million from the hospital's payroll system[83]. Additionally, identity theft has been an all too common result of cyber-attacks. In 2011 an unknown percentage of Sony's 77 million persons PlayStation Network had their credit card information stolen off the network. According to certain known hacker websites, the list of information was worth hundreds of thousands of dollars to those who stole it[84].

Computer systems have become ubiquitous in our lives, used for daily activities of residents, as well as critical in supporting and operating the life/ safety, transportation, business, and government operations infrastructure which residents and businesses rely on operating problem free. All levels of government must ensure that security is up-to-date and must be watchful for emerging trends or negative impacts. More serious attacks can focus on corrupting vital data, or cause critical infrastructure outages.

The State understands that computers are now part of our everyday lives, and that their security is critical to commerce, education, and our entertainment. The State of Missouri concern about cyber security has led to the creation of the Information Technology Services Division (ITSD) Cyber Security Awareness site at: http://cybersecurity.mo.gov/ which provides residents with information on safe

[83] DHS Daily Open Source Infrastructure Report -2 May 2013
[84] http://www.huffingtonpost.com/2011/04/29/playstation-network-data-for-sale_n_855381.html

computing. Businesses in the state will have to remain vigilant as cyber security issues are a constant threat to them and their customers. In addition, good government organizations, such the Missouri's Sheriff's Association, which recently fell victim to a cyber-attack, may be targeted by persons who are looking to negatively impact civic and civil society organizations[85]. Small scale disruptions can focus on promoting disinformation and propaganda, denying service to legitimate computer users, and spread electronic viruses.

Cyber impacts on State and national infrastructure organizations such as utility companies which provide critical services could cause widespread impacts. It is reported that the deregulated energy market may be most susceptible to cyber impacts. Power supply impacts have been noted in a variety of national studies and were common in news reports in the past number of years, particularly after the East Coast Blackout of 2003. It should be noted that many utilities have begun to undergo modernization and to increase infrastructure security to reduce these risks.

[85] http://www.stltoday.com/news/local/metro/missouri-sheriff-s-association-targeted-in-widespread-cyberattack/article_c15168b8-be08-11e0-a325-001a4bcf6878.html

3.7.15 Hazardous Materials Release (Fixed Facility Accidents/Transportation Accidents)

448 state-owned facilities and 12 state-leased facilities were determined to have high potential for on-site hazardous materials based on their use as laboratories, chemical storage, flammable storage, herbicide storage, or fuel-related uses.

Table 3.7.15a and Figure 3.7.15.1 summarizes the State-owned facilities that may contain hazardous materials based on their use.

Table 3.7.15a Hazardous Materials Facilities by County

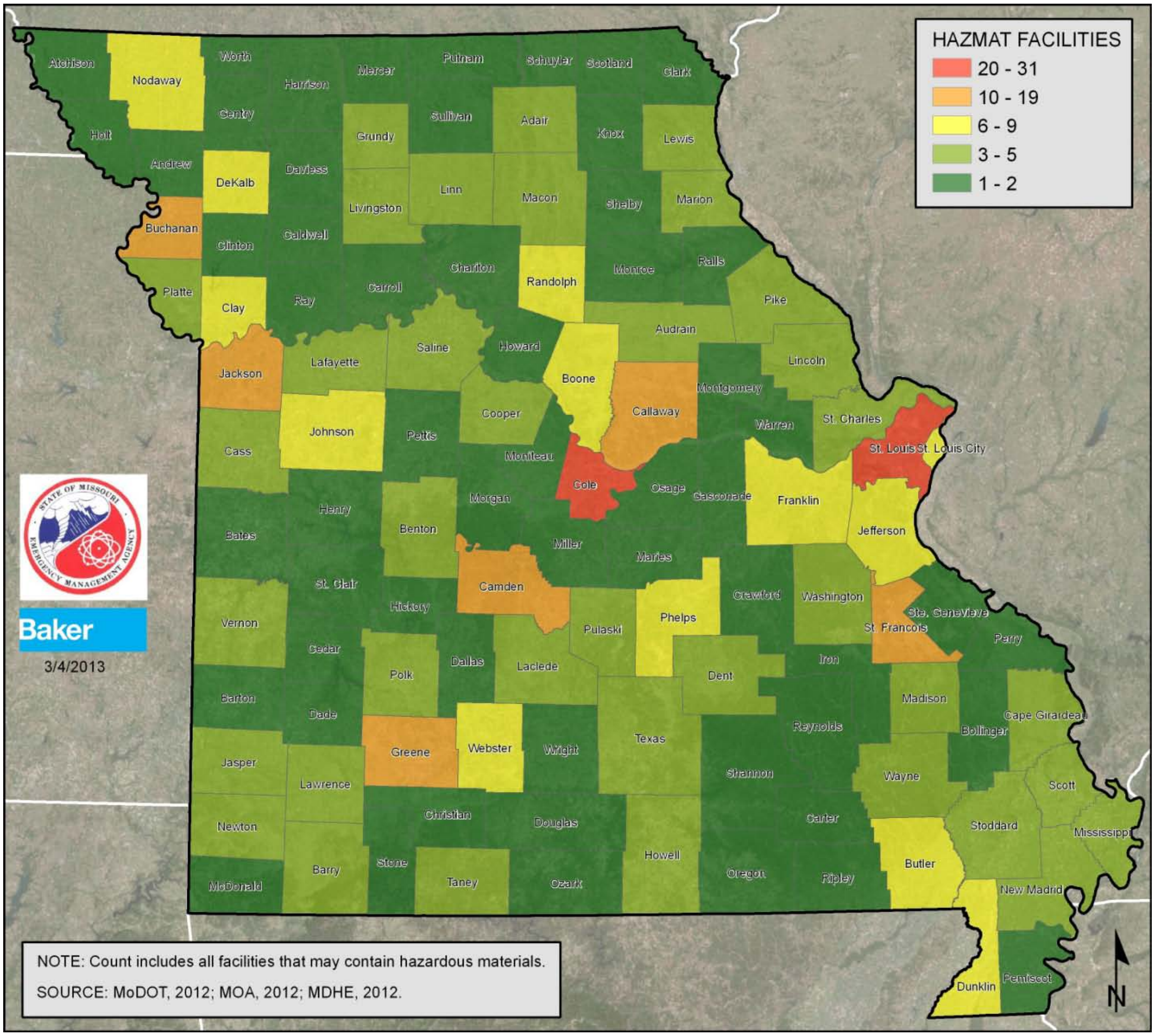
County	Number of Facilities with Potential for HAZ-MAT
Adair	4
Andrew	1
Atchison	1
Audrain	4
Barry	3
Barton	2
Bates	1
Benton	3
Bollinger	2
Boone	9
Buchanan	13
Butler	7
Caldwell	1
Callaway	17
Camden	14
Cape Girardeau	5
Carroll	1
Carter	2
Cass	3
Cedar	2
Chariton	1
Christian	2
Clark	2
Clay	6
Clinton	1

County	Number of Facilities with Potential for HAZ-MAT
Cole	22
Cooper	5
Crawford	2
Dade	1
Dallas	1
Daviess	1
DeKalb	7
Dent	3
Douglas	1
Dunklin	7
Franklin	6
Gasconade	1
Gentry	1
Greene	13
Grundy	4
Harrison	1
Henry	2
Hickory	2
Holt	2
Howard	2
Howell	3
Iron	1
Jackson	19
Jasper	5
Jefferson	6
Johnson	7
Knox	1
Laclede	4
Lafayette	4
Lawrence	4
Lewis	3
Lincoln	4
Linn	4
Livingston	5

County	Number of Facilities with Potential for HAZ-MAT
Macon	4
Madison	3
Maries	1
Marion	5
McDonald	2
Mercer	1
Miller	2
Mississippi	3
Moniteau	2
Monroe	2
Montgomery	1
Morgan	1
New Madrid	3
Newton	5
Nodaway	7
Oregon	1
Osage	2
Ozark	2
Pemiscot	1
Perry	2
Pettis	2
Phelps	7
Pike	3
Platte	4
Polk	3
Pulaski	3
Putnam	1
Ralls	1
Randolph	8
Ray	2
Reynolds	2
Ripley	1
Saline	5
Schuyler	1

County	Number of Facilities with Potential for HAZ-MAT
Scotland	1
Scott	5
Shannon	1
Shelby	1
St. Charles	5
St. Clair	1
St. Francois	14
St. Louis	31
St. Louis City	9
Ste. Genevieve	1
Stoddard	3
Stone	2
Sullivan	1
Taney	3
Texas	4
Vernon	4
Warren	1
Washington	5
Wayne	4
Webster	7
Worth	1
Wright	2
Total	**460**

Figure 3.7.15.1 - Counties housing state owned facilities with chemicals in inventory



Most hazardous material releases do not usually have an effect on infrastructure, particularly underground infrastructure. Some critical infrastructure uses hazardous materials to operate such as chlorine for water treatment and PCB's for electric transformers. Similarly, the contamination of the water supply may be treated like a hazardous material release. Propane, oil, and natural gas, necessary fuels for heating, can also be hazardous if released during their delivery due to their explosive potential. Transportation may be limited if a key roadway or railway is blocked by an incident. See Figure 3.7.15.2 showing the major transportation routes in the state.

Possible losses to structures include:

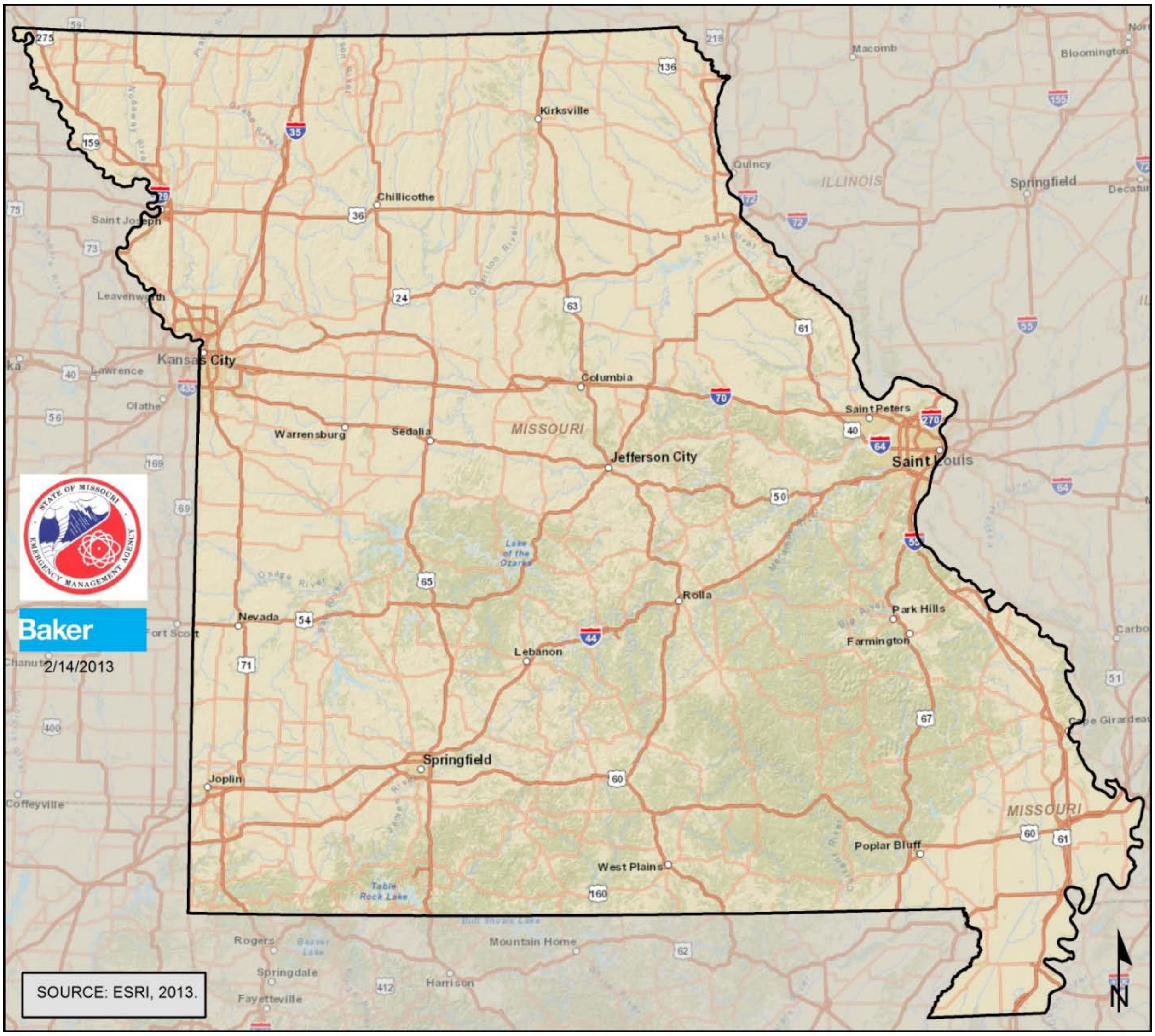
- Inaccessibility
- Contamination
- Structural and contents losses, if an explosion is present
- Possible economic losses include:

- Business closures and associated business disruption losses

Possible ecologic losses include:

- Loss of wildlife
- Habitat damage
- Reduced air and water quality

Figure 3.7.15.2 - Major transportation routes through the State of Missouri



The U.S. EPA's Toxic Release Inventory (TRI) program, tracks hazardous materials release and disposal data for US counties and states. According to the 2011 annual report (the most recent data), there were over 73 million pounds of chemicals released in Missouri. The majority of the releases were on-site land and underground. These releases are generally disposals to land on-site. However, the TRI does note many substances that have been safely disposed in the County. Disposals include antimony, lead compounds, polycyclic aromatic compounds, styrene, and xylene. The TRI data does not provide data regarding the effect on the public of releases or disposals of hazardous materials.

With a hazardous material release, whether accidental or intentional, there are potentially exacerbating or mitigating circumstances that will affect its severity or impact. Mitigating conditions are precautionary measures taken in advance to reduce the impact of a release on the surrounding environment. Primary and secondary containment or shielding by shelteringin-place protects people and property from the harmful effects of a hazardous material release. Exacerbating conditions, characteristics that can enhance or magnify the effects of a hazardous material release include:

- **Weather conditions:** affects how the hazard occurs and develops
- **Micro-meteorological effects of buildings and terrain:** alters dispersion of hazardous materials
- **Non-compliance with applicable codes (e.g. building or fire codes) and maintenance failures (e.g. fire protection and containment features):** can substantially increase the damage to the facility itself and to surrounding buildings

3.7.16 Mass Transportation Accidents

Additional research was conducted to determine if there was additional non-quantifiable data that could add information or provide a better understanding of vulnerability of facilities. This information is provided for review purposes only and has not been incorporated into the mitigation analysis. The information determined to be of significance is provided below.

In general terms mass transportation is defined as shared transportation modes which are open to the general public for use. Systems are designed to provide transportation within either a close or open framework. Closed systems, such as subway or bus systems are systems that move passengers within a set of defined locations and are controlled by a single entity, open systems, such as airports have entry and exit points that are controlled by many entities, public and private. Travel modes include: heavy rail, subway, bus, coach, trolley, trams, trolleybus, ferries, paratransit, and airplanes. Across the State many of these transportation modes are available to the public.

In addition to mass transportation systems, commercial vehicle travel is also sometimes included in this category. Non-passenger rail operations are also sometimes added to this category. Accidents involving commercial vehicles can be significant due to the high levels of damage that can occur with heavy vehicle impacts. Accidents involving freight rail operations will usually include state and federal agencies as interstate commerce rules will require a wide-level of analysis to determine the cause of the accident and for the development of corrective actions. Both commercial vehicle and freight operations can involve the transport of hazardous materials. The inclusion of hazardous materials can upgrade a small accident into a major incident, involving local, state and federal assets to reduce the risk of environmental contamination, limit damage to property and eliminate injury to the local population.

While road accidents occur within the transportation network, accidents that involve mass transportation accidents are less common than regular passenger and commercial vehicles. Nationally, roadway incidents are on the decline. Accidents which include moderate number of injured are managed locally and covered under normal life/safety operations. Larger incidents are defined as mass casualty incidents and are handled locally usually with involvement of organizations supported through mutual aid agreements.

Even as the probability of accidents are rare, air travel accidents are always treated with strong levels of response and post event investigation due to the high severity of an accident. Any accident or “near-miss” will become a local and statewide effort. National safety agencies may also participate in an incident if deemed appropriate.

3.7.17 Nuclear Power Plants (Emergencies and Accidents)

Table 3.7.17a below lists the counties within the 50 mile radius of the two nuclear power plants (Callaway and Cooper) that could impact Missouri in the event of an emergency or accident as well as the two counties in which University of Missouri (Columbia and Rolla) research reactors are located (See Section 3.3.17). The darker shaded counties are those that are within the 10-mile radius of a nuclear power plant and the lighter shaded counties are within the 50-miile radius. This table provides counts and values of state-owned facilities as well as counts and rent value of state-leased facilities. It should be noted that this analysis considers all facilities that fall within counties that are wholly or partially in the radius zones.

Table 3.7.17a State-owned and Leased Facilities in Counties within 50-mile Radius of Nuclear Power Plants and Research Reactor Emergency Planning Zones

County	Replacement Value	Total State-owned Facilities	Critical State-owned Facilities	Total # of State-leased facilities	State-leased Critical Facilities
Andrew	$1,280,032	14	12	2	0
Atchison	$975,472	12	8	4	1
Audrain	$89,128,914	44	26	7	1
Boone*	$19,292,336	105	64	18	1
Callaway	$246,509,534	125	64	5	0
Cole	$864,026,606	383	120	109	0
Cooper	$762,572	66	35	6	0
Crawford	$5,091,765	49	13	5	1
Franklin	$23,749,720	118	51	5	0
Gasconade	$3,665,569	20	14	3	0
Holt	$4,259,517	37	12	5	2
Howard	$6,948,750	12	9	3	0
Lincoln	$12,650,754	142	49	5	0
Maries	$853,648	7	5	2	0
Miller	$20,459,482	225	84	6	1
Moniteau	$47,920,685	47	14	4	3
Monroe	$4,118,550	48	4	3	0
Montgomery	$6,608,445	38	18	5	0
Nodaway	$35,792,032	38	24	7	0
Osage	$6,887,838	13	8	5	0
Phelps**	$47,190,160	53	25	8	0
Pike	$86,888,776	47	26	4	0
Ralls	$853,648	9	5	4	0
Randolph	$82,308,843	70	29	8	0
St. Charles	$37,813,068	127	98	18	1

County	Replacement Value	Total State-owned Facilities	Critical State-owned Facilities	Total # of State-leased facilities	State-leased Critical Facilities
Warren	$3,587,475	21	13	7	8

*University of Missouri-Columbia in Boone County is the location of one of the research reactors; ** University of Missouri-Rolla in Phelps County is the location of one of the research reactors.

The State of Missouri has a combined 1,870 facilities in the counties within the 50-mile radius of nuclear facilities. Of these, 830 are considered to be critical. The total replacement value of these facilities exceeds $1.6 Billion. It is important that these state facilities understand the potential danger of being within the 50-mile radius of a reactor. These nuclear facilities have planning requirements meant to ensure a certain level of planning and preparedness for each facility. Being aware of these planning opportunities and participating where possible may better prepare the state facilities for an incident.

3.7.18 Public Health Emergencies/Environmental Issues

State-owned facilities are not directly impacted by this hazard. A research review was conducted to determine if there was additional non-quantifiable data that could add information or provide a better understanding of vulnerability of facilities. This information is provided for review purposes only and has not been incorporated into the mitigation analysis. The review showed that while state-owned facilities are not directly impacted by this hazard, the citizens and communities in which these facilities reside could be directly and indirectly impacted. The information determined to be of significance is provided below.

First, a public health or environmental incident could provide a primary impact; the most common and most recent experience would be that of a severe or pandemic influenza event. A severe event could have an impact to a widespread segment of the population and could remain a threat for a long period of time. The Missouri Department of Health and Senior Services would be heavily involved in response to a pandemic incident. Many State agencies and programs exist to help citizens and businesses prepare for and reduce transmission risks. Medical information is available, particularly during flu season and at all times citizens are encouraged to create family plans, and to keep informed on current events that may impact them and their homes. Other incidents that would have a public health and environmental impact would be terrorist attacks using nuclear, biological or chemical materials. The results from even minor incidents of these types would have large impacts on the surrounding environment and could indirectly impact state facilities.

Secondly, a review of available information does show that a public health or environmental emergency could emerge as the result of another incident or event. For example, poor sanitary conditions and the lack of sanitation in the aftermath of a weather related event such as a hurricane or tornado could lead to an increase in waterborne illness or more serious impacts. Critical to the recovery process is ensuring that public health issues are immediately addressed to reduce the risk of such incidents occurring.

3.7.19 Special Events

Data is not available to quantify vulnerability or estimated losses as a result of incidents at special events. However, special events do occur at state-owned facilities on an ongoing basis.

A special event can be defined as a non-routine activity within a community that brings together a large number of people.

The State of Missouri is home to thirteen public universities. In addition, there are thirty-nine private four-year institutions in the state. These universities host special events regularly throughout the year. These include athletic events, visits from high-profile individuals and large gatherings like graduations. These occurrences are generally open to the public, and thus can expose a large number of people to a potential event.

In addition to the universities within the state, Missouri is home to multiple professional sports teams. While the teams are privately owned, many of the stadiums in which they play receive public funds. These teams generally draw crowds in the tens of thousands. These large crowds are drawn into public areas, and can expose the attendees to a variety of hazards. The Edward Jones dome (Home to the St. Louis Rams) and the Scottrade Center (Home to the St. Louis Blues) are enclosed arenas, and can help protect attendees from weather-related events like thunderstorms, winter storms, etc. Busch Stadium (Home to the St. Louis Cardinals) is an open-air stadium. This leaves attendees exposed to the potential weather hazards like thunderstorms, excessive heat and high wind events.

Regardless of the venue, or the time of year, large public gatherings will leave attendees susceptible to a variety of hazards. Attendees can be susceptible while traveling to and from these events. Special events present a strain to community and state resources by their very nature. The addition of a weather-related or other hazard can serve to exacerbate the situation.

3.7.20 Terrorism

Data is not available to quantify vulnerability or estimated losses as a result of terrorism incidents that might impact state-owned facilities. However, a research investigation was conducted to determine if there was additional non-quantifiable data that could add information or provide a better understanding of vulnerability of facilities. This information is provided for review purposes only and has not been incorporated into the mitigation analysis. The information determined to be of significance is provided below.

The 2012 Threat and Hazard Identification and Risk Assessment (THIRA) identifies major threats for the state of Missouri as well as the implications for the state should an event occur. Chemical Terrorist Attack (Non-Food) is listed as one of the hazards applicable for the state of Missouri. The report quantifies the potential for impact as the entire state of Missouri consisting of 114 Counties, 961 cities, 9 regions, 69,704 sq/mi and 6,010,688 people (Missouri Office of Homeland Security, 2012). A terrorist attack could impact any portion of the land, population, or any state facility, depending on the scale of the event.

Missouri is home to a wealth of organizations that focus on homeland security and counterterrorism. The state has three fusion centers that gather, analyze, and share intelligence information, and has more than one Joint Terrorism Task Force (JTTF). Two centers, the St. Louis Terrorism Early Warning Group fusion center and the Kansas City Regional TEW Interagency Analysis Center keep inventories of the critical infrastructure and key resources in each region. The critical infrastructure information is protected in order to safeguard the facilities from terrorist attacks. A protective security advisor from the Department of Homeland Security (DHS) is stationed in St. Louis in order to assist the region in protecting critical infrastructure. One of the important functions of the DHS advisor is to conduct building or property security assessments with owners of infrastructure. The state implemented Regional Homeland Security Oversight Committees (RHSOC) that covers the same nine regions as the Highway Patrol Troop. The FBI has field offices in both St. Louis and Kansas City, but also have remote offices scattered throughout the rest of the state (Priest and Arkin, 2013).

Missouri's State Emergency Management Agency (SEMA) has organized a Homeland Security Regional Response System (HSRRS) to improve emergency response to various hazards and build capabilities, including terrorist neutralization as a region. An initiative called Project Homeland has started in Missouri and three other pilot states to collect intelligence and GIS data from various agencies to assist in protecting critical infrastructure in Missouri (Missouri Office of Homeland Security, 2013).

Though state facilities in Missouri are still vulnerable to terrorist attack, the planning mechanisms, organizations, agencies, and resources that are organized within the state help to reduce the overall risk as well as mitigate the impact should an event occur.

3.7.21 Utilities (Interruptions and System Failures)

The primary impact to state-owned facilities as a result of the loss of utilities is the inability to provide continuous state government services. The Office of Administration Facilities Management, Design & Construction (FMDC) manages many of the state owned facilities in Missouri. The State uses physical and environmental security controls in order to protect their systems from data loss due to utility interruption. State agencies are instructed to maintain battery backup power onsite in addition to a 24 hour fuel supply for power generators if they are present at facilities (MOA, 2007). Another guideline suggests that state facilities should consider providing an uninterruptible power source (UPS) to maintain operations during events (MSU, 2012).

Utility interruptions can occur in any part of the state at any time of year. Harsh weather conditions such as lightning strikes, high winds, heavy rain, and ice storms can cause trees to fall and damage electric power lines and equipment or gas lines. The National Weather Service produces an Ice Impact Index to estimate the potential utility interruptions based on the weather conditions prior to an ice storm. The index ranges from 1 to 5 and increases in severity as it increases in number, estimating that the potential for longer outages increases as the conditions worsen. Though the vulnerability of state-owned facilities has not yet been quantified, it could be estimated for discrete events by using this index (NWS, 2012). Earthquakes are another natural hazard that can lead to utility service interruption. The same state facilities vulnerable to earthquakes are also vulnerable to utility interruption or failure. See Section 3.7.4 for Earthquake Facility Vulnerability.

In Macon, Missouri, part of their combined heat and power system (CHP) can be used to disconnect from the local grid if there is an outage in order to continue running an ethanol plant. The system is owned and operated by the City, and has kept the plant running during recent outages (USCHPA, 2010).

The State of Missouri Emergency Management Agency (SEMA) has emergency generators that they can loan out to critical state or private facilities as needed during events. This reduces the overall vulnerability of facilities when they can rely on back-up power sources until the main systems are restored (SEMA, 2013).

3.8 Climate Change Impacts

This plan is prepared with the understanding that Climate Change may impact state mitigation planning and the hazards it addresses. Depending upon the research sources and methods, a variety of changes, severities and outcomes have been predicted in regards to climate change. However, for the purposes of this plan, a general understanding that: the climate is changing, these changes are and will have an effect on the hazards within Missouri, the type and severity of the known hazards are changing and increasing, and that a dynamic planning approach will be needed to keep a resilient edge on hazard planning, will be used.

The National Oceanic Atmospheric Administration (NOAA) National Climatic Data Center (NCDC) tracks many different types of meteorological and climate information that can be used to get a general understanding the trends, or lack thereof, within a geological region and time frame. This information was used to inform this plan on the potential impacts of Climate Change on the hazards that Missouri addresses.

As an indicator of changing climate, during 2011 Missouri experienced some of the worst floods, droughts, tornado outbreaks, wildfires and extreme weather events in the history of the nation. Below are only some of the considerations of climate change that was incorporated into the mitigation plan.

Flooding

According to the NOAA National Climatic Data Center, (http://www.ncdc.noaa.gov/cag/time-series) precipitation (both rain and snow) within the state has been steadily increasing at an average of +0.22 inches each decade since 1895. The recent decade has provided interesting data. For example, within Missouri 2012 recorded the some of the lowest below average precipitation numbers in the history of the state at -0.41 inches below 41.08 (the state annual average); while 2008 recorded some of the highest above average precipitation numbers, at +0.64 inches above 41.08. With hotter summers that melt off the winter snows quicker combined with the increased precipitation during the wet seasons it is generally believed that flooding will become more severe in upcoming decades.

This makes planning for flooding within Missouri particularly challenging, as some years may have next-to-no flooding, while other years will have record flooding. The state will have to maintain an attitude of resilience with an eye for climate change when planning so as to avoid developing in potentially future flood zones.

Dam Failure

As it will be mentioned in the flooding and winter weather hazards of this climate change section, flooding has been both infrequent and more severe, depending upon the year and changing patterns. While dams may have been adequately built for flooding at the time, future trends may outclass the construction and limits of older dams. Improvements, alternative means of run off and both upstream and downstream planning efforts may need to be used to stave of the increased impacts on the dams within Missouri. As older dams are re-built or de-classified, a forward thinking approach to climate change will need to be interwoven in the design and development of newly constructed and rebuilt dams.

Levee Failure
Like dams, levees are built to a standard with certain limitations. As the climate change increases the stressors and complicates the factors in which those limits may be exceeded, it is important for Missouri to adequately maintain and repair the many levees within the state.

Earthquakes
While climate change may not directly affect fault zones, subtle differences in temperature, soil, and water tables, can exacerbate an already primed fault line. While most communities take into account the building codes for known earthquake intensities, it may be beneficial to also tie in climate change in order to see what additional issues may rise up.

Land Subsidence
The changes in precipitation and droughts can be an important factor in planning for land subsidence. Additionally, flooding changes and earthquakes also can affect the land subsidence in Missouri. Urban planning and infrastructure will be affected by the climate changes that occur. This plan takes into account those factors when planning for land subsidence.

Thunderstorm
While most meteorological hazards exist within the context of a thunderstorm, thunderstorms themselves pose a significant threat as well. The high winds, powerful downdrafts, hail, lightning and most significantly rain all can have severe impacts upon a population. Climate change has increased the severity of thunderstorms as of late. The more drastic shifts, caused by climate change, between wet/dry and hot/cold air are significant ingredients to severe thunderstorms.

Tornado
The outbreak of tornadoes in 2011, of which the deadly Joplin, MO tornado was a part of, only highlights the changes that our climate is going through. While Missouri is in the “tornado alley” and it is not unheard of to have severe tornadoes (3 of the 10 deadliest tornadoes touched down in MO) the 2011 outbreak showed how even the most modern technology cannot predict every outcome. As the storms become more severe and tornadoes become a part of the norm, Missouri will need to research ways to counteract the increase in activity. This plan considers the future demands of stronger buildings, better warnings, and faster responses.

Winter Weather
For Missouri, the NCDC shows a steady increase in precipitation, including winter weather precipitation. The increase in precipitation has led to large snow falls in short periods of time that then quickly melt off. These large snow falls take a toll on aging infrastructure, including power lines, water pipes, other utilities as well as roads and bridges. Many of these affects are harder to account for as they have long term repercussions as the infrastructure breaks down over time until failure. As the number of elderly in the nation continues to increase the risk of power-outages and other utility failures have severe consequences with isolated and immobile special populations.

Drought
The ongoing drought that Missouri is experiencing is one of the more severe since the 1960s. Wide spread drought throughout the region can have economic, social, and health risks to communities.

Climate change makes it difficult to predict and prepare for long and severe droughts, though they have been more frequent.

Heat Wave

According to the NOAA National Climatic Data Center (http://www.ncdc.noaa.gov/cag/time-series) temperatures within the state have been steadily increasing at an average of +0.1 Degrees Fahrenheit each decade since 1895. The year 2012 recorded some of the highest recorded temperatures in the history of the nation. Heat, like extreme cold has strong negative effects on isolated and immobile populations. If power, water, or other critical infrastructure is damaged, large numbers of special populations would be at risk of heat related illnesses and possibly death.

Fires

Wildfires are susceptible to climate change as they depend on wind, precipitation, drought conditions, fuel, and other factors that are controlled by climate. As the climate changes it is not unreasonable to assume that wild fire will become more frequent, and more severe. Particularly as populations expand into areas that previously experienced wildfires. Missouri will have to factor in urban sprawl and climate change into its future planning.

Chemical, Biological, Radiological, Nuclear, Explosive Attack

While not typically considered an issue in CBRNE Attacks, Climate Change can have long term impacts in modeling plumes and HazMat patters. Wind directions, temperatures, jet streams and water flow patterns all play crucial parts in planning for, mitigating against, and responding to CBRNE Attacks.

Public Health

Climate has a lot to do with diseases and disease control. Wet humid climates can allow new diseases to mutate and spread at an alarming rate. With the modern transportation capabilities, combined with the constant changes in climate and mutating diseases, it is important to understand the challenges that may arise during an epidemic or a pandemic. Issues such as, is it an airborne pathogen or do certain temperatures enhance its incubation period, are important to calculate into the planning process. Climate change can play a factor in staving off or promoting out breaks.

Summary

This section has shown how climate change is affecting the many factors that form the hazards that Missouri must address. This only increases the need to incorporate a dynamic approach to planning as climate change continues to evolve and change the hazards as we know them. A long term, forward thinking approach to planning and mitigating these hazards will need to incorporate a component for climate change.

3.9 Summary and Conclusions

The results of this analysis are useful in many ways, including, but not limited to the following:

- Based on the updated risk assessment utilizing Hazus Level 2 analysis, the State's high risk to floods is quantified for the entire state and the relative risk by county is known. As additional DFIRM depth grids are available for integration in the HAZUS 100-year flood scenario, the accuracy of the flood vulnerability analysis will increase.
- Certain counties in southeastern Missouri are at risk to multiple high-priority hazards, including floods, tornadoes, earthquakes, and severe winter weather.
- The risk assessment for state facilities has been greatly improved with better information and data from the State's Office of Administration (which manages facility data for 10 of the State's Departments), Department of Transportation, Department of Higher Education, and Department of Elementary and Secondary Education.
- Earthquake continues to be high consequence but low probability event that has the potential to impact Missouri on a regional scale. Improvements in available data including analysis using Level II Hazus analysis and the 2010 census information are helping to refine loss estimations.
- The different state partners, especially the US Army COE Silver Jackets program, have been very engaged with this plan update. This has helped to provide additional information to Risk Management Team.
- Knowledge about risk associated with natural hazards in Missouri is improving through better understanding of the complexities and dynamics of risk, how levels of risk can be measured and compared, and the myriad factors that influence risk. An understanding of these relationships is critical for the development of mitigation strategies, and the making of informed decisions to manage risk.
- The risk assessment provides a baseline for policy development and comparison of mitigation alternatives. The data used for this analysis present a current picture of risk in Missouri. Updating this risk "snapshot" with future data will enable comparison of the changes in risk with time. Baselines of this type can support the objective analysis of policy and program options for risk reduction in the State. Missouri's population growth and development trends are continuing to increase, thus the current risk will only increase if risk reduction measures are not planned and implemented.
- The risk assessment provides a comparison of risk among the hazards addressed. The ability to quantify the risk to the priority hazards relative to one another helps in a balanced, multi-hazard approach to risk management at each level of governing authority. This analysis provides a systematic framework to compare and prioritize the very disparate hazards that are present in Missouri, and provides the necessary information for the State Risk Management Team to incorporate a mitigation strategy to focus resources based on priority hazards and the most threatened populations and property.

3.10 Bibliography

3.10.1 Dam Failure

- Federal Emergency Management Agency. www.fema.gov.
- Missouri Department of Natural Resources (MDNR). Division of Geology and Land Survey. "Maintenance, Inspection and Operation of Dams in Missouri." 1991.
- MDNR. Inventory of Dams in Missouri Compiled by DNR, Dam and Reservoir Safety Program, October 2009
- MDNR. Division of Dam Safety. Telephone Conversations with Paul Simon
- MDNR, Geological Survey and Resource Assessment Division, Dam and Reservoir Safety Program, Dam Safety Publication No. 3, "Rules and Regulations of the Missouri Dam and Reservoir Safety Council, 1994, http://www.dnr.mo.gov/env/wrc/docs/rules_reg_94.pdf
- Stanford University's National Performance of Dams Program, http://npdp.stanford.edu/index.html
- U.S. Army Corps of Engineers
- U.S. Army Corps of Engineers Civil Works Program. "Congressional Submission Fiscal Year 2006: Southwestern Division." www.usace.army.mil/cw/cecwb/just_states/just_2006/SWD.pdf. 2005.
- U.S. Army Corps of Engineers Kansas City District. "Tuttle Creek Dam Safety Assurance Program." http://www.nwk.usace.army.mil/projects/tcdam/project-description.htm. 2004.

3.10.2 Drought

- Cummings, Ian and Rick Montgomery. "Drought's wide impact likely to last for years." The Kansas City Star. July 23, 2012. Retrieved at: http://www.kansascity.com/2012/07/21/3716735/dry-as-a-bone-droughts-wide-impact.html
- Darkow, Grant L. "Missouri Weather Patterns and Their Impact on Agriculture." Department of Atmospheric Science. University of Missouri. Columbia, Missouri.
- Guinan, Pat. "Drought Impact, December 2002." University of Missouri. www.mcc.missouri.edu/imedec02.pdf.
- Hays, Charles R. and Don E. Miller. Missouri Drought Response Plan. Missouri Department of Natural Resources: Division of Geology and Land Survey. 1995. Retrieved at: http://www.dnr.mo.gov/pubs/WR44.pdf
- Hu, Q. and S. Feng, et al. Missouri Climate Atlas for Design of Land Application Systems. 2004.
- Jenkins, Jason. "Tree rings help research of droughts" Missouri Ruralist. January, 2006. Retrieved at: http://web.missouri.edu/~guyetter/mor37.pdf
- Missouri Department of Natural Resources: Division of Geology and Land Survey (Missouri DNR). Hydrologic Extremes in Missouri: Flood and Drought. Missouri State Water Plan Series, Volume V: Water Resources Report Number 49. 1997. Retrieved at: http://www.dnr.mo.gov/pubs/WR49.pdf
- MDNR. "Missouri Drought Response Plan." 2002. www.MDNR.mo.gov/geology/wrp/wr69.pdf.
- MDNR. "The Palmer Drought Severity Index." "Missouri Drought Susceptibility Map." www.MDNR.mo.gov/geology/wrp/wr69.pdf.
- MDNR. "September 19, 2006, Interim Drought Status Map."
- MDNR. Drought Information: www.MDNR.mo.gov/geology/droughtupdate.htm.
- MDNR. "February 13, 2007, Interim Drought Status Map."

- Missouri Department of Natural Resources: Water Resources Center (Missouri DNR). State Water Plan. 2013. Retrieved at: http://www.dnr.mo.gov/env/wrc/statewaterplanmain.htm
- National Agricultural Statistics Service (NASS). Missouri: Crop Progress and Condition. 2013. Retrieved at: http://www.nass.usda.gov/Statistics_by_State/Missouri/Publications/Crop_Progress_and_Condition/
- National Climatic Data Center (NCDC). Billion-Dollar Weather/Climate Disasters. 2012. Retrieved at: http://www.ncdc.noaa.gov/billions/events
- National Climatic Data Center (NCDC). Storm Events Database. 2013. Retrieved at: http://www.ncdc.noaa.gov/stormevents/
- National Oceanic and Atmospheric Administration (NOAA). Special Climate Summary – 96/2. June 1996. Retrieved at: http://www.cpc.ncep.noaa.gov/products/special_summaries/96_2/
- National Remote Sensing Centre (NRSC). Agricultural Drought. November 2012. Retrieved at: http://www.dsc.nrsc.gov.in/DSC/Drought/index.jsp?include1=homelink2_b1.jsp&&include2=homelink2_b2.jsp
- National Weather Service (NWS). Drought: Public Fact Sheet. May 2006. Retrieved at: http://www.nws.noaa.gov/om/brochures/climate/DroughtPublic2.pdf
- National Weather Service (NWS). Severe Drought Persists Throughout the Region: Kansas City/Pleasant Hill, MO. National Weather Service Weather Forecast Office. 2013. Retrieved at: http://www.crh.noaa.gov/eax/?n=drought
- Park, Haeyoun and Kevin Quealy. "Drought's Footprint." The New York Times. July 19, 2012. Retrieved at: http://www.nytimes.com/interactive/2012/07/20/us/drought-footprint.html?smid=pl-share
- Risk Management Agency (RMA/USDA). 2009 Missouri Crop Insurance Profile. 2009. Retrieved at: http://www.rma.usda.gov/pubs/2011/stateprofiles/missouri09.pdf
- Risk Management Agency (RMA/USDA). 2011 Missouri Crop Insurance Profile. 2011. Retrieved at: http://www.rma.usda.gov/pubs/2011/stateprofiles/missouri10.pdf
- USDA Risk Management Agency, insured crop losses, October 2009
- U. S. Drought Monitor. www.drought.unl.edu
- U.S. Drought Portal. Palmer Drought Severity Index. National Integrated Drought Information System. 2013. Retrieved at: http://www.drought.gov/drought/content/products-current-drought-and-monitoring-drought-indicators/palmer-drought-severity-index
- University of Missouri: College of Agriculture, Food, and Natural Resources. Significant Weather Events of the Century for Missouri. Missouri Climate Center. 2013. Retrieved at: http://climate.missouri.edu/sigwxmo.php

3.10.3 Earthquakes

- Atkinson, William. "The Next New Madrid Earthquake." Carbondale, Illinois. Southern Illinois University Press. 1989.
- Bolt, Bruce, A. "Earthquakes." 2nd Edition. New York: W.H. Freeman. 1988.
- Center for Earthquake Research and Information. www.ceri.memphis.edu/usgs.
- Fuller, Myron L. "The New Madrid Earthquake." Washington: Government Printing Office. 1912. Reprinted by Southeast Missouri State University. 1989.
- Hughes, E.A. "Safety Overrides All Nuclear Concerns." Electric World. March 1, 1976.

- Mid-America Earthquake Center at the University of Illinois, “Impact of Earthquakes on the Central USA Report 08-02” Urbana, Illinois. 2008, http://mae.ce.uiuc.edu
- Missouri Department of Natural Resources. www.dnr.missouri.gov/geology.
- Morgan, Lael. “Earthquake Survival Manual.” Seattle: Epicenter Press. 1993.
- National Earthquake Information Center. www.neic.usgs.gov./neis/states/mssour/hazards.html.
- Nuttli, Otto W. “The Effects of Earthquakes in the Central United States.” Marion, Illinois: Central United States Earthquake Consortium. 1987. Reprinted by Southeast Missouri State University. 1990.
- Penick, James Lal, Jr. “The New Madrid Earthquakes.” Columbia, Missouri: University of Missouri Press. 1981.
- State Emergency Management Agency (SEMA). Earthquake Program Information and Overview Fact Sheets: www.sema.dps.mo.gov/EQ.htm
- Stewart, David M. “Damages & Losses From Future New Madrid Earthquakes.” Cape Girardeau: Southeast Missouri State University. 1994.
- Stewart, David M., and Ray B. Knox. “The Earthquake That Never Went Away.” Marble Hill, Missouri: Gutenberg-Richter Publications. 1993.
- USDA Risk Management Agency, insured crop losses, October 2009
- USGS Earthquake Hazards Program, information of preparedness and predictions related to the New Madrid Seismic Zone, www.usgs.gov/hazards

3.10.4 Levee Failure

- American Society of Civil Engineers, “So You Live Behind a Levee”, 2010
- CBS News, http://www.cbsnews.com/stories/2007/05/09/national/main2778061.shtml
- Entrepreneur Magazine, Winter, 2006; Floodplain development—learning from the Great Flood of 1993; http://www.entrepreneur.com/tradejournals/article/161065854.html.
- FEMA, Missouri DFIRM Status, October 2009
- The National Levee Challenge: Levees and the FEMA Flood Map Modernization Initiative, September 2006: *Interagency Levee Policy Review Committee report to FEMA.* See http://www.fema.gov/plan/prevent/fhm/lv_report.shtm
- National Levee Safety Program Act of 2007, http://www.emforum.org/vforum/lc071212.htm.
- Preliminary Report of the Scientific Assessment and Strategy Team, 1994; http://desastres.usac.edu.gt/documentos/pdf/eng/doc5646/doc5646-8a.pdf
- SEMA Situation Report, March 18, 2008 http://sema.dps.mo.gov/SitReps/SITREPMAR182008%2010%20am.pdf
- U.S. Army Corps of Engineers, Levee Safety Program, http://www.usace.army.mil/CEPA/FactSheets/Pages/LeveeSafetyProgram.aspx
- Water Resources Development Act, November 8, 2007, http://thomas.loc.gov/cgi-bin/query/D?c110:6:./temp/~c110pqqCqG

3.10.5 Fires (Structural, Urban, and Wild)

- Conservation Commission of Missouri (CCM). Missouri Forest Facts. 2013. Retrieved at: http://mdc.mo.gov/about-us/get-know-us/missouri-forest-facts

- Eastern Area Coordination Center (EACC). 2005 Eastern Area Interagency Mobilization Guide. Retrieved at: http://www.fs.fed.us/eacc/library/mob_guide/Chapter_40.pdf
- Federal Emergency Management Agency. 2000. Federal Funds Authorized to Help Fight Missouri Wildfires. http://www.fema.gov/news-release/2000/03/10/federal-funds-authorized-help-fight-missouri-wildfires.
- Federal Emergency Management Agency (FEMA). Missouri Camden Fire Complex (FM-2292). Disaster Declarations. March 9, 2000. Retrieved at: http://www.fema.gov/disaster/2292
- Krepps, Bob. Vantage Point, The other side of conservation. Missouri Conservationist. September 2003, Vol. 64, Issue 9. Retrieved at: http://mdc.mo.gov/conmag/2003/09/vantage-point
- Missouri Department of Conservation (MDC). Fire Reporting: Wildfire Data Search. 2013. Retrieved at: http://mdc4.mdc.mo.gov/applications/FireReporting/Report.aspx
- Missouri Department of Conservation. 2013. On-line Address: http://mdc.mo.gov .
- Missouri Department of Conservation. State Map. 2012. Retrieved at: http://mdc4.mdc.mo.gov/applications/moatlas/StateMap.htm
- Missouri Department of Conservation, Wildfire Reports, http://mdc4.mdc.mo.gov/applications/FireReporting/Report.aspx
- National Fire Incident Reporting System
- Missouri Department of Public Safety: Fire Safety – Office of the State Fire Marshal (MDFS). Firefighter Training and Certification. 2013. Retrieved at: http://www.dfs.dps.mo.gov/programs/training/
- Missouri Department of Public Safety: Fire Safety: Office of the State Fire Marshal (MDFS). Fire Incident Reporting System. 2011. Retrieved at: http://dfs.dps.mo.gov/investigations/fire-incident-reporting-system.asp
- Missouri Department of Public Safety: Fire Safety – Office of the State Fire Marshal (MDFS). Fire Safety Investigations. 2013. Retrieved at: http://dfs.dps.mo.gov/investigations/
- Missouri Department of Public Safety: Fire Safety: Office of the State Fire Marshal. 2013. http://www.dfs.dps.mo.gov/
- Missouri Department of Public Safety: Fire Safety – Office of the State Fire Marshal (MDFS). Investigations and Enforcement. 2013. Retrieved at: http://dfs.dps.mo.gov/programs/investigations/
- Missouri Department of Public Safety: Fire Safety – Office of the State Fire Marshal (MDFS). Permits for Sale of Fireworks. 2012. Retrieved at: http://www.dfs.dps.mo.gov/permits/fireworks-sales-permits.asp
- Missouri Department of Public Safety: Fire Safety – Office of the State Fire Marshal (MDFS). Special Services. 2013. Retrieved at: http://dfs.dps.mo.gov/investigations/special-services.asp
- MO-IMAS Task Force. Missouri Systems Concept of Operational Planning for Emergencies MoSCOPE). October 18, 2011. Retrieved at: http://www.dfs.dps.mo.gov/documents/forms/MO_815-F0072.pdf
- Missouri Secretary of State (MO SOS). Code of State Regulations. 2013. Retrieved at: http://www.sos.mo.gov/adrules/csr/current/11csr/11csr.asp
- National Fire Incident Reporting System (NFIRS). Fire Statistics. 2013. Retrieved at: http://www.usfa.fema.gov/statistics/
- US Census Bureau (US Census). 2010 Census. Retrieved at: http://www.census.gov/2010census/
- United State Fire Administration (USFA). State Fire Death Rates. 2009. Retrieved at: http://www.usfa.fema.gov/statistics/estimates/states.shtm

- U.S. Fire Administration National Fire Data Center (USFA). Fire in the United States 2003-2007 (15th ed.). 2009. Retrieved at: http://www.usfa.fema.gov/downloads/pdf/publications/fa_325.pdf
- University of Missouri Extension (UME). MU Fire and Rescue Training Institute. MU Extension Annual Report, FY 2009. Retrieved at: http://extension.missouri.edu/main/working4mo/frti.aspx

3.10.6 Extreme Temperature

- Adams, Christopher R. “Impacts of Temperature Extremes.” Cooperative Institute for Research in the Atmosphere – Foothills Research Campus, Colorado State University. 1997. Retrieved at: http://sciencepolicy.colorado.edu/socasp/weather1/adams.html
- Blezinger, Steve, PhD., PAS. “Monitor Cattle Closely for Heat Stress.” Cattle Today Online. www.cattletoday.com/archive/2001/July/Ct159.shtml. 2001.
- Bouchama, A. Thermophysiology and clinical management of heat related illness. Riyadh King Faisal Specialist Hospital and Research Centre. 2007. Retrieved at: http://www.euro.who.int/__data/assets/pdf_file/0004/112882/E91347_Annex_heatwaves_info.pdf
- Center for Disease Control and Prevention (CDC). Emergency Preparedness and Response: About Winter Weather. 2013. Retrieved at: http://emergency.cdc.gov/disasters/winter/about.asp#extremecold
- CNN. “St. Louis struggles without power.” CNN – Weather. July 24, 2006. Retrieved at: http://edition.cnn.com/2006/WEATHER/07/23/st.louis.blackout/
- Dewell, Dr. Grant. “Heat Stress in Beef Cattle.” Iowa State University College of Veterinary Medicine – Veterinary Diagnostic and Production Animal Medicine. August 2010. Retrieved at: http://vetmed.iastate.edu/vdpam/extension/beef/current-events/heat-stress-beef-cattle
- Federal Emergency Management Agency (FEMA). “President Declares Emergency for Missouri.” July 21, 2006. Retrieved at: http://www.fema.gov/news-release/2006/07/21/president-declares-emergency-missouri
- McGinley, Susan. “The Agriculture Research Complex, ‘New Facility Focuses on Livestock Industry Needs’.” The University of Arizona, College of Agriculture and Life Sciences. http://ag.arizona.edu/pubs/general/resrpt2002/2.pdf. 2002.
- Milhollin, Ryan, and Ray Massey. “Crop Insurance in Missouri.” University of Missouri Extension – Agricultural Exonomics Extension. 2012. Retrieved at: http://extension.missouri.edu/p/MP749
- Missouri Department of Health and Senior Services (Missouri DHSS). Heat Precautions. Hyperthermia. 2013. Retrieved at: http://health.mo.gov/living/healthcondiseases/hyperthermia/heatprecautions.php
- Missouri Department of Health and Senior Services (Missouri DHSS). Hyperthermia. 2013. Retrieved at: http://health.mo.gov/living/healthcondiseases/hyperthermia/index.php
- Missouri Department of Health and Senior Services (Missouri DHSS). Hyperthermia Mortality by Age, Missouri 2000-2011. 2011. Retrieved at: http://health.mo.gov/living/healthcondiseases/hyperthermia/pdf/hyper4.pdf
- Missouri Department of Health and Senior Services (Missouri DHSS), Hyperthermia Deaths, 1980-2011. 2011. http://health.mo.gov/living/healthcondiseases/hyperthermia/pdf/hyper1.pdf

- Missouri Department of Health and Senior Services (Missouri DHSS), Hyperthermia Mortality by Geographic Area, Missouri 2000-2011. 2011. http://health.mo.gov/living/healthcondiseases/hyperthermia/pdf/hyper2.pdf
- Missouri Department of Health & Senior Services (MDHSS). Hypothermia. 2013. Retrieved at: http://health.mo.gov/living/healthcondiseases/hypothermia/index.php
- Owen, James. “Summer’s Dog Days are Here-And Getting Hotter.” National Geographic News. July 16, 2004. Retrieved at: http://news.nationalgeographic.com/news/2004/07/0714_040714_summerdogdays_2.html
- National Weather Service (NWS). “Day 3 Forecast Daily Maximum Heat Index (Deg F).” NWS-NOAA. July 2009. Retrieved at: http://www.nws.noaa.gov/os/heat/images/bchi_day3.gif
- National Weather Service (NWS). “Heat: A Major Killer.” Office of Climate, Water, and Weather Services. May 24, 2013. Retrieved at: http://www.nws.noaa.gov/os/heat/index.shtml
- National Weather Service (NWS). “Heat Index .” 2013. http://www.nws.noaa.gov/os/heat/images/heatindex.png.
- National Weather Service (NWS). “Heat Wave: a Major Summer Killer.” 2005. Retrieved at: http://www.nws.noaa.gov/om/brochures/heat_wave.shtml
- National Weather Service (NWS). “The Historic 2012 Heat Wave.” 2012. Retrieved at: http://www.crh.noaa.gov/lsx/?n=07_08_2012
- National Weather Service (NWS). “St. Louis, MO.” National Weather Service Weather Forecast Office. 2008. Retrieved at: http://www.crh.noaa.gov/lsx/print_localdata.php?loc=pns&data=PNS_071806.txt
- National Weather Service (NWS), Wind Chill Chart. 2001. Retrieved at: http://www.nws.noaa.gov/om/windchill/
- SEMA. “Missouri Summer Safety Week.” www.sema.state.mo.us/heatlightning.pdf.
- Sheridan, Scott C. and Laurence S. Kalkstein. “Progress in Heat Watch-Warning System Technology.” American Meteorological Society. December 2004. Retrieved at: http://www.climateknowledge.org/heat_waves/Doc1005_Sheridan_Kalkstein_HWWS_%20BAMS_2004.pdf
- University of Missouri – Missouri Climate Center (MCC). 2013. Climate of Missouri. Retrieved at: http://climate.missouri.edu/climate.php.
- US Census Bureau – American Community Survey (ACS). 2006-2010. American Community Survey 5-Year Estimates. Age and Sex. 2010. Retrieved at: http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ACS_10_5YR_S0101&prodType=table
- US Census Bureau. 2007-2011 American Community Survey 5-Year Estimates. Age and Sex. 2011. Retrieved at: http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ACS_11_5YR_S0101&prodType=table
- US Department of Agriculture (USDA). “Recognizing Heat Stress.” Agricultural Research Service. 2007. Retrieved at: http://www.ars.usda.gov/main/docs.htm?docid=15625USDA Risk Management Agency, insured crop losses, October 2009
- Weatherwise. “Deadly & Costly: 1980 Heat Wave.” Vol. 34, Iss. 3. 1981. Retrieved at: http://dx.doi.org/10.1080/00431672.1981.9931959

3.10.7 Land Subsidence/Sinkholes

- Anderson, Neil L. and Jonathan L. Robison. "Geophysical Investigation of the Delaware Avenue Sinkhole, Nixa, Missouri." Sinkholes and the Engineering and Environmental Impacts of Karst. 2008. Retrieved at: http://ascelibrary.org/doi/abs/10.1061/41003(327)7
- Arkansas Geological Survey (AGS). Geohazards. 2012. Retrieved at: http://www.geology.ar.gov/geohazards/landsubsidence.htm
- Associated Press. "Woe! Lake begone! 23-acre body of water disappears in St. Louis suburb. June 11, 2004. Retrieved at: http://www.msnbc.msn.com/id/5191079/ns/us_news-weird_news/t/woe-lake-begone/#.UPSFjeTBFK8
- Christian County. Christian County Zoning Regulations. January 22, 1993. Retrieved at: http://christiancountymo.gov/downloads/PandZ/zoning/Zoning%20Regulations/Zoning%20Regulations.pdf
- Gouzie, Douglas and Gary Pendergrass. "Investigation and Remediation of the 2006 Nixa, Missouri, Collapse Sinkhole." Environmental & Engineering Geoscience, February 2009, v. 15, p. 13-27. Retrieved at: http://eeg.geoscienceworld.org
- Greene County. Green County Design Standards – Section 107 Sinkholes and Karst Features. April 5, 1999. Retrieved at: http://www.greenecountymo.org/resource_management/pdf/sw-107.pdf
- Greene County. 2009 Greene County Multi-Jurisdictional Hazard Mitigation Plan: Community Profiles. September 2009. Retrieved at: http://www.greenecountymo.org/file/oem/mitigation/section_2.pdf
- Groundspeak. Exeter Sinkhole. 2006. Retrieved at: http://www.waymarking.com/waymarks/WM10CN_Exeter_Sinkhole
- Kaufmann, James E. Sinkholes. U.S. Department of the Interior: U.S. Geological Survey. July 2007. Retrieved at: http://pubs.usgs.gov/fs/2007/3060/pdf/FS2007-3060.pdf
- Lissalou66. "Ore Cart." March 28, 2009. Retrieved at: http://www.flickr.com/photos/lissalou66/3392567685/
- Missouri Department of Natural Resources: Division of Geology and Land Survey. (Missouri DNR). Missouri – The Cave State. June 2008. Retrieved at: http://dnr.mo.gov/pubs/pub664.pdf
- Missouri Department of Natural Resources (Missouri DNR). MO 2010 Sinkholes (SHP). 2010. Retrieved at: ftp://msdis.missouri.edu/pub/Geological_Geophysical/MO_2010_Sinkholes_shp.zip
- Missouri Department of Natural Resources (Missouri DNR), Division of Geology and Land Survey, cave, sinkhole, and mine information, http://www.dnr.mo.gov/geology/geosrv/geores/gdamhp.htm
- Missouri Department of Natural Resources (DNR). 2013. Geological Survey Program – Sinkholes in Missouri. Retrieved at: http://www.dnr.mo.gov/geology/geosrv/envgeo/sinkholes.htm.
- United States Geological Survey (USGS). Sinkholes. The USGS Water Science School. 2013. Retrieved at: http://ga.water.usgs.gov/edu/earthgwsinkholes.html
- USGS, http://pubs.usgs.gov/fs/2007/3060/pdf/FS2007-3060.pdf
- University of Missouri, MSDIS, sinkholes data, http://www.msdis.missouri.edu/datasearch/VectDisplayResults.jsp?currDispPageNum=1.
- University of Missouri, MSDIS, cave data, http://www.msdis.missouri.edu/datasearch/VectDisplayResults.jsp?currDispPageNum=1 .

- University of Missouri, MSDIS, mine data, http://www.msdis.missouri.edu/datasearch/VectDisplayResults.jsp?currDispPageNum=1
- University of Missouri-Columbia(UMC). Missouri Spatial Data Information Service. 2011. Retrieved at: http://msdis.missouri.edu/
- Van Dyke, Jim. "That Sinking Feeling – a Void, a Collapse." Missouri Resources: Volume 20:Number 1. Spring/Summer 2003. Retrieved at: http://www.dnr.mo.gov/magazine/2003-springsummer.pdf
- Veni, George et. al. Living with Karst: A Fragile Foundation. American Geological Institute. 2001. Retrieved at: http://www.agiweb.org/environment/publications/karst.pdf
- Wichary, Marcin. "Untitled." September 4, 2008. Retrieved at: http://www.flickr.com/photos/mwichary/2829883860/

3.10.8 Severe Thunderstorms

- National Climatic Data Center, Storm Events Data, http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwEvent~Storms
- USDA Risk Management Agency, insured crop losses, October 2009
- USDA Census of Agriculture, 2007
- National Lightning Safety Institute, Lightning Fatalities, Injuries, and Damage Reports in the United States, http://www.lightningsafety.com/nlsi_lls/fatalities_us.html
- University of South Carolina, Hazards and Vulnerability Research Institute, Department of Geography, Social Vulnerability Index.

3.10.9 Severe Winter Weather/Snow/Ice/Severe Cold

- Association of Missouri Electrical Cooperatives, storm damage estimated 2006-2009
- Federal Emergency Management Agency, Get Disaster Information, www.fema.gov/hazard/index.shtm
- Missouri Department of Transportation, annual costs for snow and ice removal, January 2010.
- National Weather Service, Storm Data and Unusual Weather Phenomena. www.nws.noaa.gov.
- National Oceanic and Atmospheric Administration (NOAA) National Climatic Data Center, http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms

3.10.10 Riverine Flooding

- Missouri Department of Natural Resources. "Missouri Water Atlas." 1986.
- State Emergency Management Agency (SEMA). "After Action Report. The 1995 Missouri Flood."
- SEMA. "The Response, Recovery and Lessons Learned from the Missouri Floods of 1993 and 1994."
- U.S. Department of Commerce. "Flash Floods and Floods, A Preparedness Guide." National Oceanic Association Administration. 1992.
- Missouri Department of Health. "Flood Mortality, Summer-Fall 1993."
- National Weather Service. "Missouri Severe Weather Awareness Week 2007" www.nws.noaa.gov.
- SEMA. "Floods of 1993-1999." "Disaster Declarations 1993-1995, 1998, 1999, 2000, and 2003."
- Missouri Department of Health. "Flood Mortality Statistics, Summer/Fall 1993."

- SEMA. “Maps – Spring, Summer, and Fall 1993 Floods, Spring 1994 Flood, Spring 1995 Flood, July 1998 Flood, Fall 1998 Flood, Spring 1999 Flood, Summer 2000 Flood (Counties/Cities Declared).”
- HAZUS MH-MR4 and HAZUS MH-MR2
- DFIRM Depth Grids for 28 Missouri Counties and the City of St. Louis, AMEC Earth & Environmental
- BureauNet, National Flood Insurance Program Statistics, Flood Insurance Coverage, Claims, Repetitive Loss Properties, and Severe Repetitive Loss Properties
- University of Missouri Center for Agricultural, Resource, and Environmental Systems, Extent of Summer 1993 Flood Map
- U.S. Army Corps of Engineers. “Record High Water Stages. Distribution of Levee Failures.” 1993.

3.10.11 Tornadoes

- Association of Missouri Electrical Cooperatives, storm damage estimated 2006-2009
- NOAA, National Climatic Data Center, http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms
- NWS, Tornado, Death and Injury Statistics: 1950-July 31, 2009
- NWS, Enhanced F Scale for tornado damage and indicators, www.spc.noaa.gov/faq/tornado/ef-scale.html
- NWS, www.crh.noaa.gov/sgf
- SEMA, Disaster Declarations for Missouri Tornadoes since 1975.

3.10.12 Attack (Nuclear, Conventional, Chemical, and Biological)

- Federal Emergency Management Agency (FEMA). 2003. U.S. Department of Homeland Security. Antiterrorism— Hazard Mitigation: It’s Not Just for Natural Disasters Anymore. www.fema.gov/fima/antiterrorism. Accessed June 19, 2003.
- FEMA. 2003. U.S. Department of Homeland Security. Planning—How-To Guide #7: Integrating Human-Caused Hazards into Mitigation Planning. www.fema.gov/fima/planning_toc6.shtm. Accessed June 19, 2003
- FEMA. 2003. U.S. Department of Homeland Security. Hazards—Terrorism. www.fema.gov/hazards/terrorism. Accessed June 19, 2003.
- FEMA. 2003. U.S. Department of Homeland Security. Hazards—Fact Sheet: Terrorism. www.fema.gov/hazards/terrorism/terrorf.shtm. Accessed June 19, 2003.
- FEMA. 2003. U.S. Department of Homeland Security. Hazards—Backgrounder: Terrorism. www.fema.gov/hazards/terrorism/terror.shtm. Accessed June 19, 2003.
- FEMA. 2003. U.S. Department of Homeland Security. Hazards— Fact Sheet: Radiological Accidents. www.fema.gov/hazards/nuclear/radiolof.shtm. Accessed June 19, 2003.
- Federation of American Scientists (FAS). 2002. Intelligence Resource Program. National Security Directives (NSD) [Bush Administration, 1989-93]. www.fas.org/irp/offdocs/nsd/index.html. Accessed June 19, 2003.
- FAS. 2002. Chemical Weapons Program—Japan. www.fas.org/nuke/guide/japan/cw. Accessed June 21, 2003.
- FAS. 2002. Chemical Weapons—United States. www.fas.org/nuke/guide/usa/cbw/cw. Accessed June 22, 2003.

- First World War.com Website. 2002. Weapons of War: Poison Gas. www.firstworldwar.com/weaponry/gas.htm. Accessed June 19, 2003.
- Henry L. Stimson Center. 2002. Chemical Weapons: History and Controls. www.stimson.org/cbw. Accessed June 22, 2003.
- The Homeland Security Council, Planning Scenarios Executive Summaries Created for Use in National, Federal, State, and Local Homeland Security Preparedness Activities, David Howe, July 2004.
- Johns Hopkins University, Electronic Mass Casualty Assessment and Planning Scenarios (EMCAPS) program for predicting casualties. 2006
- RAND Science and Technology Policy Institute. 2001. Protecting Emergency Responders—Lessons Learned from Terrorist Attacks. Conference Proceedings. New York City. December 9–11.
- The White House Website. 2003. The National Strategy for Homeland Security: Office of Homeland Security. www.whitehouse.gov/homeland/book/index.html. Accessed June 19, 2003.
- United States Bomb Data Center, Bureau of Alcohol, Tobacco, Firearms, and Explosives. Reports of U.S. Bombing Incidents and Thefts of Explosives, 2004-2007.
- U.S. Department of the Army. 2002. Army Regulation 380-86. Classification of Former Chemical Warfare, Chemical and Biological Defense, and Nuclear, Biological, Chemical Contamination Survivability Information. March 15, 2002.
- U.S. Department of Defense, DefenseLINK web site. 2003. Iraq and the Use of Chemical Weapons. www.defenselink.mil/news/Jan2003/n01232003_200301234. Accessed June 22, 2003.
- University of Yale Law School. 2002. The Avalon Project. The Atomic Bombings of Hiroshima and Nagasaki. www.yale.edu/lawweb/avalon/abomb. Accessed June 22, 2003.
- Worldwide Incident Tracking System website 2009. National Counterterrorism Center (NCTC). www.wits.nctc.gov. Accessed November 20, 2009.

3.10.13 Civil Disorder

- Missouri Day By Day. Missouri State Library References Department.
- Missouri Highway Patrol, 50 Years. Missouri State Library, Reference Services Department.
- The U.S. Department of Homeland Security (DHS). 2003. “National Response Plan (NRP), available through the National Emergency Management Association web page at ttp://www.fema.gov/national-response-framework
- Disaster and Emergency - Civil Disorder. Los Angeles County Sheriff, Emergency Operations Bureau.
- Haddock, David D. and Polsby, Daniel D. Understanding Riots. Cato Journal, Vol. 14, No. 1.
- Johns Hopkins University, Electronic Mass Casualty Assessment and Planning Scenarios (EMCAPS) program for predicting casualties. 2006
- Trojanowicz, Robert C. Preventing Civil Disturbances, A Community Policing Approach. The National Center for Community Policing. Michigan State University.
- Missouri Department of Corrections Division of Adult Institutions website. http://doc.mo.gov/division_adult.php.
- Missouri Department of Corrections Division of Adult Institutions. http://doc.mo.gov/division/dai/map_inst.php.

- Worldwide Incident Tracking System website 2009. National Counterterrorism Center (NCTC). www.wits.nctc.gov. Accessed November 20, 2009.

3.10.14 Hazardous Materials Release (Fixed Facility and Transportation Accidents)

- Missouri Department of Transportation, Rail Freight Carriers System Map, 2009
- United States Environmental Protection Agency, National Priorities List, Superfund Program, http://www.epa.gov/superfund/sites/npl/
- Missouri Department of Natural Resources, Emergency Environmental Response, Incident Reports, http://www.dnr.mo.gov/env/esp/meerts.htm, 2012.
- Missouri Department of Natural Resources, Emergency Environmental Response, Missouri Environmental Emergency Response Tracking System (MERRTS) http://www.dnr.mo.gov/env/esp/meerts.htm, 2012.
- Missouri Highway Patrol, Division of Drug and Crime Control, Meth/Special Projects Unit, Methamphetamine Statistics, http://www.mshp.dps.missouri.gov/MSHPWeb/Publications/Reports/2012StatewideLabIncidents.pdf
- State of Missouri, Missouri Office of Administration, Purchasing, State Contracts Listing, http://oa.mo.gov/purch/cgi/display.cgi?contnum=C307154001.

3.10.15 Nuclear Power Plants (Emergencies and Accidents)

- Ameren Website, Calloway Plant Frequently Asked Questions, 2009 http://www.ameren.com/callaway/
- Callaway Facility, telephone conversation with Luke Graessle of AmerenUE, June 2003.
- Callaway Facility, "Missouri Nuclear Accident Plan."
- Cooper Facility, "Missouri Nuclear Accident Plan."
- Cooper Facility, telephone conversation with James Kelsay of Nebraska Public Power District, June 2003.
- Cooper Nuclear Station, Cooper Nuclear Station Fact Sheet, 2009 http://www.nppd.com/Newsroom/cns_brochure.pdf
- Federal Emergency Management Agency website, Nuclear Power Plant Emergency, 2009, http://www.fema.gov/hazard/nuclear/index.shtm
- Hughes, E.A., "Safety Overrides all Nuclear Concerns," Electrical World, March 1, 1976.
- U.S. Nuclear Regulatory Commission, "Reactor Safety Study," WASH 1400, Washington, D.C., October 1975.

3.10.16 Public Health Emergencies/Environmental Issues

- Centers for Disease Control and Prevention (CDC). 2006. Avian Influenza: Current Situation. www.cdc.gov/flu/avian/outbreaks/current.htm. Accessed February 12, 2007.
- CDC. 1999. Emerging Infectious Diseases. Vol. 5. No. 2. Preparing for Pandemic Influenza, the Need for Enhanced Surveillance. March-April 1999.
- CDC. 2002. National Vaccine Program Office. Influenza Pandemic Preparedness Action Plan for the United States: 2002 Update.

- CDC. 2003. National Vaccine Program Office. Pandemic Influenza: A Planning Guide for State and Local Officials (Draft 2.1). www.cdc.gov/od/nvpo/pandemicflu.htm.
- Curezone.com. 2003. Pandemics and Pandemic Scares in the 20th Century. http://curezone.com/forums/fm.asp?i=564918.
- CDC. 2003. Division of Vector-Borne Infectious Diseases. Questions and Answers about Lyme Disease. http://www.cdc.gov/lyme/faq/index.html. Accessed June 11, 2003.
- CDC. 2003. Division of Vector-Borne Infectious Diseases. CDC Lyme Disease Home Page. http://www.cdc.gov/lyme/. Accessed June 10, 2003.
- CDC. 2006. Division of Vector-Borne Infectious Diseases. Lyme Disease Data. www.cdc.gov/ncidod/dvbid/lyme/ld_statistics.htm. Accessed February 12, 2007.
- CDC. 2003. Division of Vector-Borne Infectious Diseases. St. Louis Encephalitis. http://www.cdc.gov/sle/. Accessed June 10, 2003.
- CDC. 2003. Division of Vector-Borne Infectious Diseases. Information on Arboviral Encephalitides. www.cdc.gov/ncidod/dvbid/arbor/arbdet.htm. Accessed June 10, 2003.
- CDC. 2003. Division of Vector-Borne Infectious Diseases. West Nile Virus – Questions and Answers. www.cdc.gov/ncidod/dvbid/westnile/qa/overview.htm. Accessed June 10, 2003.
- CDC. 2003. Division of Vector-Borne Infectious Diseases. West Nile Virus Basics. www.cdc.gov/ncidod/dvbid/westnile/index.htm. Accessed December 27, 2012.
- CDC. 2005. Division of Bacterial and Mycotic Diseases. Meningococcal Disease – General Information. http://www.cdc.gov/meningococcal/. Accessed February 12, 2007.
- CDC. 2006. Division of Bacterial and Mycotic Diseases. Meningococcal Disease – Technical and Clinical Information. http://www.cdc.gov/meningococcal/clinical-info.html. Accessed February 12, 2007.
- CDC. 2003. Fact Sheet - Smallpox Overview. www.bt.cdc.gov/agent/smallpox/overview/disease-facts.asp. Accessed June 10, 2003.
- CDC. 2003. Division of Vector-Borne Infectious Diseases. Fact Sheet – Basic Information About SARS. http://www.cdc.gov/sars/about/fs-SARS.html. Accessed June 10, 2003.
- CDC. 2006. National Immunization Program. Meningococcal Vaccines. http://www.cdc.gov/vaccines/pubs/vis/default.htm#mening. Accessed February 12, 2007.
- Goodson, Lori. 1998. The Manhattan (Kansas) Mercury. Pandemic. March 1, 1998.
- Infectious Disease News (IDN). 1997. Is Another Influenza Pandemic Coming Soon? May 1997.
- Missouri Department of Health and Senior Services. 2012. 2010 Annual Report. http://health.mo.gov/living/healthcondiseases/communicable/communicabledisease/reports.php.
- Missouri Department of Health and Senior Services. 2009. Bioterrorism Program H1N1 Update. http://www.dhss.mo.gov/BT_response/_H1N1Flu.html
- Missouri Department of Health and Senior Services. 2012. Bureau of Communicable Disease Control and Prevention, Influenza Like Illness Monitoring Reports. http://health.mo.gov/living/healthcondiseases/communicable/influenza/pdf/Week401213.pdf. Missouri Department of Natural Resources (MDNR). 1995. Division of Geology and Land Survey. Surface Water Resources of Missouri. Missouri State Water Plan Series. Volume 1. Water Resources Report Number 45.
- United States Environmental Protection Agency (EPA). 2013. Toxics Release Inventory (TRI) Program. TRI.NET. http://www.epa.gov/tri/tridotnet/index.html. Accessed February 12, 2007.

- Missouri Department of Natural Resources (MDNR). 2012. Water Pollution Control Program. 2012 Water Quality Report. http://www.dnr.mo.gov/env/wpp/waterquality/305b/2012-305b.pdf. Accessed February 21, 2013.
- Missouri Department of Natural Resources (MDNR). 2003. Statewide Network of Air Monitoring Air Quality Sites. http://www.dnr.mo.gov/env/esp/aqm/agmsitesmap2011.pdf. Accessed June 10, 2003.
- Rekenthaler, Doug. 1999. Health Board Website. Eighty Years Later, Threat of Influenza Pandemic Remains Large. http://www.healthboard.com/websites/Detailed/12196.html. March 1999.
- Time Magazine (Time). 1998. Vol. 151. No. 7. The Hong Kong Incident. February 23, 1998.
- U.S. Geological Survey. 2006. Disease Maps 2006. http://diseasemaps.usgs.gov/. Accessed February 11, 2007.
- World Health Organization (WHO) 2009. H1N1 Case Counts by State. http://www.who.int/cse/don/2009_8_28/en/index.html

3.10.17 Special Events

- Cable News Network (CNN), Inc. 1996. “Law officers’ quick thinking may have averted more tragedy,” news article dated July 27, 1996, available electronically at the CNN web page: www.cnn.com/US/9607/27/park.explosion.heroes/index.html.
- Jefferson City News Tribune. 2003. “St. Louis police will investigate officers’ conduct,” news article dated June 1, 2003, available electronically in the online edition at http://newstribune.com/stories/060103/sta_0601030880.asp.
- The Homeland Security Council, Planning Scenarios Executive Summaries Created for Use in National, Federal, State, and Local Homeland Security Preparedness Activities, David Howe, July 2004.
- Johns Hopkins University, Electronic Mass Casualty Assessment and Planning Scenarios (EMCAPS) program for predicting casualties. 2006
- The U.S. Department of Homeland Security (DHS). 2003. “National Response Plan (NRP), available through the National Emergency Management Association web page at www.nemaweb.org/docs/National_Response_Plan.pdf.
- The U.S. Department of Justice (DOJ). 1998. “Eric Rudolph Charged in Centennial Olympic Park Bombing,” press release dated Wednesday October 14, 1998, available electronically at www.usdoj.gov/opa/pr/1998/October/477crm.htm.
- St. Anthony Messenger Press. 1999. “The Pope Visits St. Louis,” news article in the April 1999 St. Anthony Messenger Magazine Online, available electronically at www.americancatholic.org/Messenger/Apr1999/feature1.asp.
- St. Louis Post Dispatch. 2003. “City police get set to deal with protestors,” news article dated May 7, 2003, available electronically at www.STLtoday.com.

3.10.18 Terrorism

- American Red Cross. www.redcross.org.
- American Water Works Association. www.awwa.org.
- Center for Democracy and Technology. www.cdt.org.
- Centers for Disease Control & Prevention (CDC). www.cdc.gov.

- Chemical and Biological Defense Information Analysis Center. www.cbiac.apgea.army.mil.
- Dartmouth College. Institute for Security Technology Studies. 2001. Cyber Attacks During the War on Terrorism. September 22, 2001.
- Federal Bureau of Investigation (FBI). www.fbi.gov.
- Federal Emergency Management Agency (FEMA). www.fema.gov/hazards/terrorism.
- Homeland Defense Journal. www.homelanddefensejournal.com.
- The Homeland Security Council, Planning Scenarios Executive Summaries Created for Use in National, Federal, State, and Local Homeland Security Preparedness Activities, David Howe, July 2004.
- Johns Hopkins University, Electronic Mass Casualty Assessment and Planning Scenarios (EMCAPS) program for predicting casualties. 2006
- Missouri Department of Health & Senior Services. www.dhss.state.mo.us.
- Missouri Homeland Security. www.homelandsecurity.state.mo.us.
- National Counter-Intelligence Center. www.nacic.gov.
- National Homeland Security Knowledge Base. www.twotigersonline.com/resources.
- San Louis Obispo Tribune. 2002. Agroterrorism. September 9, 2002.
- Terrorism Research Center. www.terrorism.com.
- The White House Web Page. www.whitehouse.gov.
- U.S. Army Soldier and Biological Chemical Command. www.sbccom.apgea.army.mil.
- U.S. Department of Health & Human Services, National Disaster Medical System. www.ndms.dhhs.gov.
- U.S. Department of Homeland Security. DHS Organization. www.dhs.gov/dhspublic.
- U.S. Department of Justice. U.S. Attorney Todd Graves. Western District of Missouri. Anti-Terrorism Task Force. www.usdoj.gov/usao/mow/units/attf.html.
- U.S. Department of Homeland Security. Office of Domestic Preparedness. www.ojp.usdoj.gov/odp.
- U.S. Department of Justice Programs. www.ojp.usdoj.gov.
- U.S. Department of State Office of the Coordinator for Counterterrorism. 2005. “Foreign Terrorist Organizations.” www.state.gov/s/ct/rls/rpt/fto/.
- U.S. Department of State Office of the Coordinator for Counterterrorism. 2005. “Country Reports on Terrorism 2005.” www.state.gov/documents/organization/65462.pdf.
- U.S. Department of State. Travel Warnings. www.travel.state.gov/index.html.

3.10.19 Utilities

- Association of Missouri Electrical Cooperatives. “Electric CO-Ops in Missouri.” On-Line Address:http://www.amec.org/content/missouris-electric-cooperatives.
- Energy Information Administration. 1997. “Major Interstate Natural Gas Pipelines in Central Region.” On-Line Address: www.eia.doe.gov/pub/oil_gas/natural_gas/analysis_publication/deliverability/pdf/app.pdf
- Public Service Commission (PSC). On-Line Address: http://psc.mo.gov
- Missouri Department of Natural Resources. On-Line Address: www.dnr.mo.gov/
- Missouri Department of Natural Resources. Directory of Missouri Utility and Cooperative Energy Systems, http://www.dnr.mo.gov/pubs/pub776.pdf
- Missouri State Emergency Management Agency. “Projected Earthquake Intensities Map.” On-Line Address: www.sema.dps.mo.gov/EQ%20Map.pdf.
- What is a Benefit? Guidance on Benefit-Cost Analysis of Hazard Mitigation Projects, Federal Emergency Management Agency, June 2009

It is essential that state and local mitigation policy be directed to minimize the risk of future devastation and the corresponding impact on the residents and property in the State of Missouri. This can only be accomplished by establishing workable goals and objectives that integrate the efforts of state and local governments into one cohesive mitigation strategy.

Development of a sound mitigation philosophy provides a focus that helps state and local governments identify priorities and channel their limited resources toward critical mitigation projects. This process helps government at all levels make the most effective use of available resources.

The State will continue to meet its goals and objectives by taking maximum advantage of the mitigation resources available, both present and future, to reduce the impact of natural and manmade disasters on both the residents and infrastructure of Missouri. The State will also continue to vigorously pursue methods to augment existing state and local programs by exploring and taking advantage of other opportunities, such as public-private partnerships. The State will continue to provide education and training on the benefits of a comprehensive statewide hazard mitigation program for state agencies, local governments, private enterprises, and the residents of Missouri.

The results of the planning process, which include the risk assessment, capability assessment, goal setting, and identification of mitigation measures, as well as the hard work of the SRMT led to the action plan that follows. This process helped the SRMT clearly comprehend and identify the overall mitigation strategy that guides the implementation of the action plan and the day-to-day mitigation efforts of the State. Taking all of the above into consideration, the SRMT developed this comprehensive mitigation philosophy:

- **Implement** the action plan recommendations of this plan.
- **Use** existing regulations, policies, programs, procedures, and plans already in place.
- **Monitor** multi-objective management opportunities, share and package funding opportunities, and garner broader constituent support.
- **Communicate** the hazard information collected and analyzed through this planning process so that Missouri's local governments and residents better understand where disasters occur, and what they can do to mitigate their impacts. In doing so, also publicize the success stories that have been achieved through the State's ongoing mitigation efforts.

Technical Note*: This document is a User Interfaced, Web Based Interactive Document. It has been formatted with active embedded hyperlinks throughout. There are several different types of hyperlinks. Hyperlinks within the document: Some of the hyperlinks will direct the user to specific sections of the plan where referenced information may be found. These links are identified by a blue color format.*

Hyperlinks to SEMA website: Some of the hyperlinks will direct the user to a SEMA website to access reference documents and resource data. Some of these documents are password protected and the user will be directed to obtain credentials from SEMA to gain access. These links are identified by a red color format.

Hyperlinks to external websites: These hyperlinks will direct the user to a third party website where additional information can be found. As with all hyperlinks to external sites, if the site administrator makes changes to the URL, these can expire or become non-functional. These links are identified by a green color format.

This chapter focuses on the State's hazard mitigation strategy, capabilities, and funding sources to implement mitigation measures. It is divided into six parts as shown below. The section heading hyperlinks allow you to go to a specific section or sub-section of Chapter 4:

4.1 Hazard Mitigation Goals and Objectives

Requirement §201.4(c)(3)(i):	[The state mitigation strategy shall include a] description of state goals to guide the selection of activities to mitigate and reduce potential losses.
Update §201.4(d):	[The] plan must be reviewed and revised to reflect changes in development, progress in statewide mitigation efforts and changes in priorities.

The purpose of this section is to describe the goals and objectives of the state mitigation program. In order to be effective, these goals and objectives must be achievable and they must complement both state and local mitigation strategies. They also play a role in the State's overall mitigation strategy through a balanced review and prioritization of proposed mitigation projects.

The results of these mitigation efforts are important to state and local governments, public-private partnerships, and the general public. By establishing reasonable goals and objectives, those involved in the planning process can see their efforts realized which can make a difference in other mitigation efforts.

Section 4.1.1 identifies the primary goals and objectives for the State's hazard mitigation program in prioritized order. The goals and objectives reflect the mature nature of SEMA's established statewide hazard mitigation program and have evolved over several years of state mitigation planning efforts. SEMA encourages its partners to consider these mitigation goals when developing local mitigation plans and other plans.

4.1.1 State of Missouri Mitigation Goals and Objectives

Goal 1: Implement mitigation actions that improve the protection of human life, health, and safety from the adverse effects of disasters

1.1 Maintain a robust mitigation program that addresses ways to mitigate the loss of life from disaster events. (This includes supporting the development and funding of mitigation plans and sensible mitigation projects to reduce the effects of natural hazards, future flooding, eliminate repetitive flood losses, improve safety and reduce losses during severe weather events, mitigate losses due to earthquakes, minimize losses due to terrorism, and reduce risk and losses due to high wind, tornadoes, winter storms, drought, high heat, and fire.)

1.2 Strengthen coordination with SEMA's mitigation partners and help educate them about mitigation.

1.3 Support the development of sensible enabling legislation, programs, and capabilities of federal, state, and local governments and public-private partnerships engaged in mitigation activities.

1.4 Increase public awareness of disaster risks and effective mitigation measures that protect human life.

1.5 Maintain a high level of mitigation proficiency among SEMA staff.

Goal 2: Implement mitigation actions that improve the continuity of government and essential services from the adverse effects of disasters

2.1 Support the development of sensible mitigation projects to protect key and essential facilities and services.

2.2 Continue to educate federal, state, and local public officials; educational institutions; private associations; and private business entities that provide essential services about hazards and how mitigation can reduce losses and help maintain continuity.

2.3 Educate state and local officials concerning the need to use sensible mitigation techniques for new facility construction.

2.4 Encourage maximum participation in maintaining effective state and local mitigation plans, disaster plans, and business continuity plans.

2.5 Encourage federal, state, and local officials; educational institutions; private associations; and private business entities that provide essential services to incorporate mitigation into other plans.

Goal 3: Implement mitigation actions that improve the protection of public and private property from the adverse effects of disasters

3.1 Maintain an effective mitigation program that addresses ways to mitigate the loss of property from disaster events. (This includes supporting the development and funding of mitigation plans and sensible mitigation projects to reduce the effects of natural hazards, future flooding, eliminate repetitive flood losses, improve safety and reduce losses during severe weather events, mitigate losses due to earthquakes, minimize losses due to terrorism, and reduce risk and losses due to high wind, tornadoes, winter storms, drought, high heat, and fire.)

3.2 Strengthen cooperation with SEMA's mitigation partners and help educate them about mitigating the loss of property.

3.3 Support organizations that work to help mitigate the adverse effects of disasters.

3.4 Increase public awareness of disaster risks and effective mitigation measures that protect property.

3.5 Support the National Flood Insurance Program, Community Rating System (CRS), earthquake insurance, and other programs that serve to reduce the impacts of disasters on properties.

Goal 4: Implement mitigation actions that improve the protection of community tranquility from the adverse effects of disasters

4.1 Develop, implement, and complete mitigation projects as expeditiously, effectively, efficiently, and unobtrusively as possible.

4.2 Consider sustainability issues (ecologically sound, economically viable, socially just, and humane) when developing or reviewing mitigation projects and plans.

4.3 Lead and support the work of mitigation partners to educate the general public about how mitigation can help protect communities and promote community tranquility.

4.4 Develop and provide periodic reports and success stories to federal, state, and local public officials, educational institutions, private associations, private business entities, and the public on the progress of hazard mitigation activities.

4.5 Encourage citizens and citizen organizations to support and use mitigation in plans, projects, and public outreach to increase a sense of community security and safety.

4.1.2 Process for Identifying, Reviewing, and Updating State Goals and Objectives

Missouri's SRMT developed these goals and objectives to guide the state mitigation program and the selection of actions to mitigate potential losses from hazard events. These goals and objectives represent a long-term vision for hazard reduction and enhancement of mitigation capabilities and have evolved over years of mitigation planning in Missouri.

During the 2013 update process, the goals and objectives from the 2010 plan were reviewed to determine if they still address current conditions and anticipated future needs. This was accomplished during the third planning meeting. The SRMT assessed the goals and objectives based on the process outlined in Section 6.2.2 Progress Review for Mitigation Goals, Objectives, and Activities. In addition to that process, the review was based on:

- The updated statewide risk assessment, which includes changes in growth and development, recent disasters, enhanced vulnerability assessments, and analysis of local risk assessments
- Assessment of changes and challenges in state and local capabilities since the 2010 plan
- Analysis of the similarities and/or differences of the state mitigation plan goals with local mitigation plan goals and objectives
- Identification of achieved mitigation objectives from the 2010 plan

The key issues identified in the statewide risk assessment and the analysis of local risk assessments can be found in Chapter 3 Risk Assessment. Information on the changes in state and local mitigation capabilities is summarized in Sections 4.2 State Capability Assessment and 4.3 Local Capability Assessment. The following section describes how the local mitigation plan goals and objectives were reviewed and considered during the 2013 update. Section 4.4 Mitigation Actions includes detailed and updated mitigation measures designed to meet the designated goals and objectives and progress on these objectives is evaluated in Sections 4.4 and Section 7.5 Effective Use of Available Mitigation Funding.

The SRMT concluded that the goals and objectives from the 2010 plan remain valid and continue to guide the State's mitigation philosophy. Flood mitigation and life safety remain the top priorities.

4.1.3 Review of Local Goals and Objectives

SEMA analyzed the goals and objectives of 106* Missouri local community hazard mitigation plans to assess their consistency with state goals and objectives. The analysis involved calculating the percentage of local plans that had goals similar to a goal in the 2013 Missouri State Hazard Mitigation Plan Update.

Note: 106* includes 104 local plans that have been FEMA approved, updated, and/or expired. It also includes two county plans of Laclede and Pulaski that were included in the 2013 plan update, but have never been approved by FEMA.

The results in Table 4.1.3a show that most local plans have similar goals to State Goal 1 to improve protection of life, health, and safety (82 percent) and State Goal 3 to improve protection of public and private property (87 percent). More than half of local plans have a goal similar to State Goal 2 to improve protection of continuity of government and essential services from the adverse effects of disasters. SEMA also assessed local goals that address a specific hazard and found that 26 percent of local plans have a goal related to reducing the impacts of flooding.

Table 4.1.3a Percentage of Local Plans with Similar Goals to State Plan

Missouri State Hazard Mitigation Plan Goals	Local Plans with Similar Goal
Goal 1: Improve Protection of Life, Health, and Safety	82%
Goal 2: Improve Protection of Continuity of Government and Essential Services	53%
Goal 3: Improve Protection of Public and Private Property	87%
Goal 4: Improve Protection of Community Tranquility	100%

SEMA also analyzed the local goals that differed from state goals. Table 4.1.3b lists common general goals among the local plans and the percent of plans that contained a similar goal. The third column in the table lists the percentage of local plans that had a similar objective. Because the local plans were developed by Missouri's Regional Planning Commissions, many plans in the same region had very similar goals and objectives. The SRMT concluded that the additional goals and objectives identified by the local plans, while not worded exactly the same, tended to align with State Goal 4 to improve protection of community tranquility or were similar to the State plan's objectives. While many of the local plans identified promoting public education and awareness as a goal, the SRMT views this as an objective, which is currently listed under each of this plan's goals.

Table 4.1.3b Other Common Goals and Objectives in Local Plans

Common Goals in Local Plans	Local Plans with Similar Goal	Local Plans with Similar Objective
Promote Public Information, Education, and Awareness about Hazards and Risk	53%	30%
Improve Structures and Infrastructure to Reduce Hazard Impacts	30%	34%
Manage Growth and Development in Hazard Areas	25%	22%
Establish Long-Term Risk Reduction Priorities	29%	32%
Strengthen Communication, Cooperation, and Partnerships	25%	23%
Maintain Local Economy	18%	3%

Common Goals in Local Plans	Local Plans with Similar Goal	Local Plans with Similar Objective
Secure Resources for Investment in Hazard Mitigation	32%	2%
Reduce Risk to Most Vulnerable Populations	22%	4%
Protect and Restore Natural Systems	17%	28%
Improve Warning and Emergency Systems	15%	72%
Design Policies to Limit Hazard Impacts	21%	2%

4.2 State Capability Assessment

Requirement §201.4(c)(3)(ii):	[The state mitigation strategy shall include a] discussion of the State's pre-and post-disaster hazard management policies, programs, and capabilities to mitigate the hazards in the area, including: an evaluation of State laws, regulations, policies, and programs related to hazard mitigation as well as to development in hazard-prone areas; [and] a discussion of State funding capabilities for hazard mitigation projects.

This section discusses Missouri's existing capabilities, including state agencies, programs, outreach and partnerships, plans and policies for mitigating hazards, both pre- and post-disaster. State capabilities related to development in hazard-prone areas and funding hazard mitigation projects are also discussed. During the 2013 plan update, the SRMT evaluated capabilities by identifying the changes in capabilities since the 2010 Missouri State Hazard Mitigation Plan and assessed the challenges and opportunities for improving those capabilities.

4.2.1 State Agencies and Mitigation-Related Programs and Initiatives

The roles and responsibilities of the Missouri State Emergency Management Agency (SEMA) and the other agencies involved in statewide emergency preparedness, response, recovery, and mitigation activities are outlined below. While each state agency administers its own programs, SEMA is the manager and provides leadership for the overall state mitigation strategy. The agencies work together to ensure that the various mitigation programs complement each other and work toward achieving the State's overall strategy. One way that agencies work together is by participating on the SRMT, the group responsible for the preparation and review of this plan and for state review of all mitigation initiatives.

The primary existing state programs and planning efforts that guide and regulate hazard mitigation activities are also briefly described in this section. Many of the programs are pre-disaster such as the partnerships, plans, and policies. However, post-disaster capabilities are covered as well, such as the Structural Assessment and Visual Evaluation (SAVE) Coalition, volunteer recovery organizations, State Emergency Operations Plan, and the Drought Response Plan.

State Emergency Management Agency

SEMA, a division within the Department of Public Safety, is responsible for coordinating statewide emergency preparedness, response, recovery, and mitigation activities among federal, state, and local

agencies. The SEMA director is the state coordinating officer during disasters and also serves as the governor's authorized representative and liaison to FEMA; this position is counterpart to the federal coordinating officer. During disaster operations, all departments of state government are expected to cooperate fully with requests for assistance from the SEMA director. The governor's declaration of a state emergency initiates the operation of the State Emergency Operations Plan, which is continually updated by SEMA to meet changing conditions.

SEMA's *Logistics, Resources, Mitigation and Floodplain Management Branch* services four areas important to Missouri's residents. It is comprised of the Logistics Management Section, Resources Management Section, Mitigation Management Section and the Floodplain Management Section. These sections administer the Missouri Disaster Logistics and Resources Management Programs, the Missouri Mitigation Programs, and the Missouri Floodplain Management /Floodplain Insurance Programs.

The *Logistics Section* is responsible to provide disaster logistics planning, training, preparedness, response, and recovery operations and to work hand in hand with the Resource Section. During an event, the section's staff must rapidly analyze the logistics situation which includes what local support is available and the needs required to meet that emergency. As evidenced during the many emergencies and six Presidential disasters that occurred in 2008, the Logistics Section managed more than 150 resource requests which included projected duration of resource assignment, anticipated results, projected delivery, actual delivery, possible redeployment and demobilization. They also coordinated disaster response with various districts of the U.S. Army Corp's of Engineers and county officials for the distribution of 3.6 million sandbags and pumps to county emergency management officials throughout the Missouri and Mississippi River Basin.

Since 2010 SEMA's Logistics and Resources team has been involved in the response to numerous federally declared disasters, smaller scale disasters, and local emergencies. The largest response effort during this timeframe occurred in 2011. During the spring of 2011 Missouri was affected by flooding emanating from the Mississippi River in the southeast portion of the state. As the response to the historic flooding, which included activation of the Birds-Point New Madrid Floodway, began to wrap up, Joplin and Sedalia were impacted by tornados. While the response to these events was still ongoing, another major round of flooding occurred along the Missouri river, impacting large areas in the northwest and central portions of the state and lasting into the fall.

In the two disasters declared (DR-1980 and DR-4012), over 400 resource requests were filled by logistics and resources in addition to those filled by other Emergency Support Functions, and response activities were nearly continuous for more than five months. Resources ranging from out of state ambulances and search and rescue dog teams were filled through the Emergency Management Assistance Compact, and a host of Action Request Forms were submitted for federal assistance including personnel, supplies, and technical expertise. More than 250,000 pounds of ice, over 2,300,000 sand bags from the USACE, over 12,000 tons of sand, in excess of 170,000 gallons of fuel, nearly 1000 offender laborers from the Department of Corrections, and a host of other rented, leased, and purchased items including pumps, light towers, transportation services, warehousing space, and heavy equipment were provided during the response. Numerous resources were provided by other Missouri state agencies including MoDOT, DNR, the Highway Patrol, and Division of Fire Safety, among others, to support response efforts.

More recently SEMA's logistics and resources team coordinated with key response partners including USACE, MoDOT, DNR, Corrections, private vendors and the Missouri National Guard to provide resources to communities impacted by flooding, severe storms, and straight line winds during the spring and summer of 2013. Approximately 85 resource requests were filled in relation to these events with resources provided ranging from numerous pieces of rented equipment and pumps, transportation assistance, over 500,000 sand bags, over 300 personnel, technical assistance, traffic control devices, and over 700 tons of fill materials, among others.
The *Resources Section* is a new entity that was established in May 2008 with the assistance of the Office of Administration. During the 2008 disaster events, the Resource Section worked together as a team with the Logistics Section to fill the more than 150 resource requests. This included 4.5 truck loads of ice and 4,500 deliverables during the disasters. This new section enables SEMA to greatly improve logistics and resource support for the State.

The *Mitigation Section* is designed to lessen or avoid the adverse impact that disasters inflict on lives and property of Missouri's residents and visitors. To do this, the section has administered seven hazard mitigation assistance grant programs that have helped nearly 800 Missouri counties and communities covered by FEMA-approved hazard mitigation plans qualify for these grant opportunities. Under the voluntary flood mitigation buyout programs that followed the Great Flood of 1993 and continues today, more than 4,500 residential properties have been acquired and demolished which remove them permanently from harm's way by requiring the property to be deed restricted from any future development. This helped many homeowners avoid financial harm. Additionally, mitigation grants have funded the replacements of bridges and low water crossings as well as creek bank stabilization and channelization projects to lessen the threat of future flood damage. In cooperation with Missouri's rural electric cooperatives, the Logistics, Resources, Mitigation and Floodplain Management Branch has also used mitigation grants to increase the number of NOAA weather warning transmitters, providing early warning coverage to nearly the entire state. And in recent years, the need to mitigate tornado and severe wind damage has become increasingly urgent, resulting in the growing use of mitigation funding to construct multiple school and community tornado safe rooms around Missouri.

The *Floodplain Management Section* administers the National Flood Insurance Program (NFIP). Floods are one of the most common hazards in the State of Missouri. For those who live in a mapped Special Flood Hazard Area (SFHA) and have a mortgage on their structure, federal law mandates that lenders require flood insurance. However, because most everyone is subject to flooding, all residents are eligible to purchase flood insurance if that community participates in the NFIP, even if they live outside the SFHA. The Floodplain Management Section works with the NFIP participating communities, conducting community assistance program compliance visits and providing technical assistance that ensures continued NFIP participation. The section's staff also manages much of the flood insurance rate map work performed under the federal Risk Map Program. Risk Map Strategy incorporates floodplain management with hazard mitigation by using tools such as DFIRMS, Hazus reports, and risk assessment data to deliver quality data that increases public awareness and leads to action to reduce risk to life and property. Missouri is achieving this with their "Floodplain Official's Ordinance Tool" (FOOT) and Loss Avoidance Tool (LAT) described in Section 7.4. The State of Missouri continues to promote the Community Rating System (CRS). Currently the State has 5 communities that belong to the CRS.

In addition, the Floodplain Management Section partners with the Missouri Floodplain and Stormwater Managers Association and others to offer extensive training for local floodplain managers, insurance

agents, elected officials, engineers and surveyors, lenders and realtors. As of May 2013, Missouri has 151 nationally Certified Floodplain Managers and SEMA continues to administer the Certified Floodplain Manager exam.

The *Planning and Disaster Recovery Branch* manages the All-Hazard Planning and the Disaster Recovery sections of SEMA. The All-Hazard Planning Section provides guidance and assistance to state agencies and local governments in developing and maintaining their operations plans by addressing natural and manmade hazards. This includes developing and maintaining Missouri's State Emergency Operations Plan and the Hazard Analysis, which is included in Chapter 3 of this plan. The Statewide Area Coordinator Program is part of the All-Hazards Planning Section and consists of nine area coordinators which serve as the State's liaisons to the local jurisdictions for emergency management activities. The Disaster Recovery Section is responsible for managing post-disaster recovery assistance programs, including FEMA's Individuals and Households Program and the Public Assistance Program. In particular, Section 406 Public Assistance Mitigation funds can be used in the declared disaster areas and in conjunction with identified, eligible disaster projects that will strengthen existing infrastructure and facilities to more effectively withstand the next disaster.

The *Operations, Training and Exercise Branch* of SEMA offers emergency management training opportunities for state and local emergency managers, public officials, members of volunteer relief organizations, and professionals in related fields. Although most courses are preparedness and response-related, there are also mitigation-related courses such as the Mitigation Planning Workshop for Local Governments, Earthquake Nonstructural Mitigation Workshop, Tools for Floodplain Management, and Risk Analysis. This branch also has responsibility for the Earthquake Program, which oversees various organizations and activities, including the Missouri State Seismic Safety Commission and the Structural Assessment Visual Evaluation (SAVE) Coalition.

The *Missouri Emergency Response Commission* (MERC) is also a part of SEMA. MERC is dedicated to protecting public health and the environment by assisting communities with chemical incident prevention, preparedness, response, and recovery and by receiving, processing, and reporting on chemical information received under the community right-to-know laws. Through lessons learned in exercises, training, and actual events, the MERC and its participating local emergency response committees improve local and state ability to manage and mitigate chemical incidents. Additionally they are instrumental in developing local emergency operations plans that respond to, recover from, and mitigate such incidents.

Mitigation-Related Programs and Planning

Community Buyout Program

Missouri's voluntary flood buyout program was established after the Great Flood of 1993. Since then, over 4,500 primary residences have been acquired, which allows households in flood-prone areas to voluntarily relocate out of harm's way. The acquired properties are then placed in public ownership with deed restrictions that ensure that future use of that land will not put people and property at risk to flooding disasters. The buyout program uses a mixture of funds sources, including the Hazard Mitigation Assistance grants, Public Assistance, Community Development Block Grant Program, and some financial assistance from The Salvation Army and the Interfaith Disaster Response funds. The Community Buyout Program was recognized as a model for the nation following the devastating 1993 floods. Local communities throughout the State have continued this program by using their own funds to acquire flood-prone properties. Because of the success of this program, acquisition of flood-prone structures

continues to be a priority for hazard mitigation funding in the State and in particular, the acquisition of repetitive loss structures under NFIP. More detailed information on this program can be found in Section 7.5 Effective Use of Available Mitigation Funding.

Floodplain Management Program

Missouri has an effective and proactive floodplain management program. Floodplain management personnel work to ensure that local governments, private enterprises, and citizens are aware of the benefits of participating in the NFIP. Initiatives to improve educational and technical assistance to local communities include conducting community assistance visits and training classes and inspecting sites throughout the state. The Logistics, Resources, Mitigation and Floodplain Management Branch also institutionalized an annual workshop and joint seminars with the Flood Insurance Administration. The Natural Resources Conservation Service has given SEMA grant funds for floodplain workshops.

Jurisdictions that participate in the NFIP must establish ordinances related to floodplain development. The SEMA Floodplain Management Section provides guidance and sample ordinances to communities interested in developing local floodplain programs.

Currently, the state of Missouri has 651 communities including 99 counties (includes St. Louis City) and 552 cities and towns partipate in the National Flood Insurance Program (NFIP) with approximately 30,000 flood insurance policies in force as of February 2013.

SEMA and five local governments (City of Lee's Summit, City of Jackson, City of Springfield, Greene County, and Cass County) participate in FEMA's Cooperating Technical Partners Program (CTP) and collaborate on maintaining up-to-date flood maps and other flood hazard information.

SEMA has developed a web site for helping communities with floodplain regulations and information. Included on this the web site is a SEMA-developed ordinance tool to assist locals in completing and submitting community information needed to prepare a floodplain management ordinance so that they can participate in the NFIP. This tool is called a "Floodplain Official's Ordinance Tool (FOOT). SEMA has also developed a Community Rating System Tool (CRST) to assist and promote local communities to become CRS communities. These tools are both available at the following website: http://floodplain.sema.dps.mo.gov/SEMA/.

Earthquake Program

SEMA has developed a multifaceted earthquake program designed to carry out earthquake awareness and preparedness programs; work with partners to promote earthquake loss reduction plans, practices, and policies that encourage earthquake mitigation; and to develop better response and recovery capabilities through participation in earthquake training and exercises. On an annual basis each February, the earthquake program promotes an Earthquake Awareness Month with workshops, exhibits, and speakers.

The Missouri Seismic Safety Commission is an advisory body established by the State legislature to review the overall earthquake preparedness in the State and make recommendations for the government, private sector, and residents to better mitigate the effects of a major seismic event. The commission developed a Strategic Plan for Earthquake Safety in 1997 and updated in 2007 which identifies objectives and makes recommendations for earthquake mitigation. The commission also promotes earthquake awareness activities each year at different venues throughout the State.

The Structural Assessment and Visual Evaluation (SAVE) Coalition facilitates the use of volunteer engineers, architects, and qualified building inspectors to perform damage assessments of homes and businesses following disasters such as earthquakes and tornadoes. The SAVE Coalition provides sound advice to communities and residents concerning the safety of re-entering their homes following a disaster and minimizes the need for sheltering by allowing people to return to their homes as soon as conditions are safe. Missouri statute *RSMo 44.023* provides immunity from liability for those working in disaster volunteer programs.

SEMA and the State's Executive Department worked together to write a new Catastrophic Event (Earthquake) Annex, which is in the State Emergency Operations Plan as Annex Y. The Earthquake Program Manager is responsible for maintaining this annex.

State Emergency Operations Plan

Updated in December 2012, it lays a framework that will allow the State of Missouri to save lives, minimize injuries, protect property and the environment, preserve functioning civil government, ensure constituted authority, and maintain essential economic activities in the event of an emergency or disaster, natural, technological, or otherwise. Specifically, it directs the actions of state departments and agencies in response to a variety of incidents where local need and suffering requires state assistance. Authority for the plan is set forth in Code of State Regulations 11 CSR 10-11.010, Chapter 44, Revised Statute of Missouri.

This plan emphasizes a comprehensive approach to emergency management that strives to integrate all hazards that pose a risk to the State, all phases of emergency management, and all levels of government and the private sector. Additionally, the SEOP institutionalizes the concepts and principles of the National Incident Management System and the Incident Command System into response and recovery operations conducted within the State of Missouri. It also sets the parameters for the development of local emergency operations plans and procedures.

This functional plan consists of three components: 1) The Basic Plan is the overall guide for state emergency management activities. It contains the policies and regulations that govern emergency management and assigns responsibilities for the execution of emergency functions to various state agencies and private organizations. 2) The functional annexes provide specific direction for the essential emergency functions outlined in the Basic Plan. Functions addressed by the 25 annexes include warning, damage assessment and analysis, evacuation, hazardous materials, disaster recovery, continuity of government, terrorism, and special needs. 3) Supporting documents explain how actions are to be carried out in support of each functional annex. Supporting documents include maps, charts, and resource lists that help organizations carry out their emergency responsibilities.

Local, State, and National Volunteer Groups

SEMA's statewide volunteer coordinator works to bring together local, state, and national voluntary organizations through the Missouri Disaster Recovery Partnership, community organizations active in disaster (COAD), Missouri Voluntary Organizations Active in Disaster (MOVOAD), and the Governor's Faith-Based and Community Service Partnership for Disaster Recovery. The Disaster Recovery Partnership helps communities' plan for disaster recovery by developing and implementing a holistic approach to disaster recovery that maximizes public and private resources to facilitate an efficient and effective integrated system addressing human services, housing, infrastructure, community, and

economic development issues. COADs use community disaster education, hazard analysis, training exercises, classes for community leadership, and local emergency management plans to bring awareness to residents on the four phases of emergency management. MOVOAD is dedicated to protecting public health and the environment by assisting communities with chemical incident prevention, preparedness, response, and recovery.

Disaster Resistant Communities Program

Through the State's Disaster Resistant Community Program (in conjunction with FEMA's former Project Impact program), eight Missouri communities have implemented mitigation projects in their communities. In 1998, Project Impact selected Cape Girardeau and St. Joseph to become Disaster Resistant Communities. From 1998–2000, Branson, Bolivar, Hannibal, Maryville, Neosho, and Piedmont were further selected to become Disaster Resistant Communities. SEMA worked with these communities to help them develop mitigation plans and projects by attending and facilitating multiple planning sessions with local officials, professionals, volunteer agencies, schools, and interested residents.

Local Mitigation Planning Project

Missouri's program for local hazard mitigation planning coordinates with the State's Regional Planning Commissions and Councils of Government to help local governments meet the requirements of DMA 2000. The local hazard mitigation planning project is described in more detail in Chapter 5 Coordination of Local Mitigation Planning.

Emergency Management Accreditation Program (EMAP)

This is a standards-based voluntary assessment and accreditation process for state and local governments responsible for coordinating prevention, mitigation, preparedness, response, and recovery activities for natural and manmade disasters. Accreditation is based on compliance with collaboratively developed national standards. Missouri received full EMAP accreditation in 2007. Becoming EMAP accredited means that the State has a comprehensive emergency management program on par with other top state emergency management programs.

Attorney General's Office

The Attorney General's Office represents the legal interests of the State and its agencies.

Department of Agriculture

The Missouri Department of Agriculture sets agriculture policy and provides assistance to farmers throughout the State. The Department of Agriculture is involved specifically with drought mitigation and mitigating agricultural damage from other hazard events.

Mitigation-Related Programs and Planning

Catastrophic Mortality and Associated Material Disposal, dated October 2008—This plan describes the outcome of a foreign animal disease outbreak or other natural or man-made disaster where Missouri livestock and poultry producers could be faced with the task of large-scale mortality and the disposal of other potentially contaminated materials associated with the foreign animal disease response and mitigation.

Department of Conservation

The Missouri Department of Conservation (MDC) is active in the State Emergency Operations Center (SEOC), during all state declared disasters. MDC has work teams and equipment throughout the State

which provides assistance to cities, counties, and other state agencies as necessary during disasters. MDC also participates in all pre-disaster exercises, drills, and planning teams in the State.

MDC owns many undeveloped floodplain areas that provide storage during high flows. The MDC is also a member of numerous levee districts that provide flood protection to crops and structures. All lakes owned by the Department of Conservation with dams over 35 feet high are designed in accordance with the criteria of the Dam and Reservoir Safety Council of Missouri. The safety or redundancy factor built into these dams and levee construction projects is a higher standard than for commercially constructed projects. In addition, the department owns facilities for launching and landing boats that regularly flood and are designed to be "low profile" and relatively flood-proof.

MDC also participates in a statewide wildfire control program in cooperation with the forest industry, rural fire departments, and other agencies. Prescribed burning of prairies, glades, and savannas may increase the risks of fire hazards; however, prescribed burning reduces the availability of fire fuels and the potential for future, more serious fires to develop. The Department of Conservation, in coordination with SEMA, also performs endangered species reviews for proposed FEMA-funded mitigation projects.

Mitigation-Related Programs and Planning

St. Louis Region Healthy Streams and Watersheds—aims to conserve the ecological health of those St. Louis region streams and watersheds that are still healthy, but are most threatened by pollution.

Stream Stewardship Trust Fund—is an in-lieu fee stream mitigation program. If a developer's project impacts a Missouri stream, in many cases, they must mitigate for that damage. One way to mitigate is to pay a fee to the Trust Fund, which creates a funding mechanism to protect Missouri's best streams.

Wetland Restoration Projects—MDC is involved with numerous mitigation projects throughout the State dealing with protection of wetlands, fish, wildlife, and floodplain lands. Many of these programs include the cooperation of several entities such as the U.S. Army Corps of Engineers, U.S. Fish and Wildlife, levee districts, DNR, and private landowners

Department of Economic Development

The Department of Economic Development (DED) administers the Community Development Block Grant program (CDBG) which can provide funding for hazard mitigation and disaster recovery. The DED also administers programs for "distressed and targeted" communities.

Mitigation-Related Programs and Planning

2008 Disaster Recovery: Supplemental Disaster CDBG funds were awarded to Missouri following the six separate Presidentally-declared Disasters during 2008. The funds are intended for activities related to disaster relief, long-term recovery, and restoration of infrastructure, housing and economic revitalization, and they may not otherwise replace other federal, state, or local financial assistance available for any project. The declared disasters areas for DR-1742, 1748, 1749, 1760, 1773, and 1809 were eligible for this type of assistance in Missouri.

In 2012 CDBG received a supplemental for 2011 events. Section 239 of the Department of Housing and Urban Development Appropriations Act, 2012 (Public Law 112-55, approved November 18, 2011) makes available up to $400 million, to remain available until expended, in CDBG funds for necessary expenses related to disaster relief, long-term recovery, restoration of infrastructure and housing, and economic

revitalization in the most impacted and distressed areas resulting from a major disaster declared in 2011 pursuant to the Robert T. Stafford Disaster Relief and Emergency Assistance Act of 1974.

See Chapter 7 (page 7.64) for a detailed listing of CDBG awards from 2008 to April 2010.

Department of Elementary and Secondary Education

The Department of Elementary and Secondary Education, is within the Missouri State Board of Education. According to the Missouri Constitution, "The supervision of instruction in the public schools shall be vested in a state board of education ..." (Article IX, Section 2a). This provision gives the State Board of Education general authority for public education, within limits set by the General Assembly.
The Board's major responsibilities include defining academic performance standards and assessment requirements for public schools; accrediting local school districts, establishing requirements for the education, testing, assessment, certification and recertification of all public school teachers and administrators; operating the Missouri School for the Blind (St. Louis), the Missouri School for the Deaf (Fulton), and the statewide system of Missouri Schools for the Severely Disabled; as well as overseeing federal education programs and the distribution of federal funds to school districts.

Mitigation-Related Programs and Planning

Catastrophic Event Preparation—discusses the State catastrophic event plan in collaboration with DESE, Missouri Center for Safe Schools, Missouri United School Insurance Council, and SEMA.

Department of Health and Senior Services

The Department of Health and Senior Services (DHSS) has internal emergency response plans in place, and as part of the State response the Missouri State Emergency Operations Plan has been fully tested with exercises for all aspects of response and recovery including those relating to public health, emergency response, terrorism, biological, chemical, and radiological/nuclear threats, pandemic influenza, and natural disasters. The Missouri Center for Emergency Response within the DHSS is responsible for coordinating regional and state planning for public health emergencies and disasters, including biological, chemical, and nuclear terrorism. Through partnerships with hospitals and other healthcare organizations; local entities including law enforcement agencies; and other partners, the center works to assure systems are in place to protect the health of Missourians during a public health emergency. The department also has responsibility for planning related to the Center for Disease Control and Prevention's Strategic National Stockpile, which provides life-saving medications and supplies in the event of a large health catastrophe.

The Division of Community and Public Health (DCPH) is responsible for areas of surveillance, disease investigation, and environmental public health. In order to further detect and analyze events of public health importance, DHSS has enhanced surveillance programs through the Public Health Emergency Preparedness grants. The Public Health Event Detection and Assessment Unit in DCPH manages the BioTerrorism Surveillance System and the Electronic Surveillance System for the Early Notification of Community-Based Epidemics (ESSENCE) to provide for early event detection. The ESSENCE system works by placing chief complaints from each emergency department visit into one or more syndromic groups. The system then determines whether the number of visits in the syndromic category was higher than expected for that hospital, county, or zip code. The system can also be used to increase situational awareness by augmenting information about a known health event and its consequences.

Mitigation-Related Programs and Planning
Missouri's Planning Guide for Local Mass Prophylaxis: Distributing and Dispensing the Strategic National Stockpile, dated October 2003—this plan describes how DHSS can request, receive, and distribute the Strategic National Stockpile to local public health agencies, hospitals, and EMS providers.

Missouri Pandemic Flu Response Plan, dated December 2011—this plan is to provide an effective response to pandemic influenza resulting from natural causes or a terrorist attack. Pandemic plans describe strategies of preparedness, response and recovery to attempt to decrease illnesses and deaths during the pandemic period to manageable levels (i.e., that do not overwhelm the critical infrastructures of the State), and to promote community resiliency and rapid recovery.

The response plan will be implemented after a novel influenza strain begins to spread readily from person to person. The plan is geared toward action and specific responsibilities and designed to complement existing DHSS emergency response plans.

Ready in 3 Program—provides tools and materials free of charge to schools and families in Missouri for taking three steps you can take to prepare for many kinds of emergency situations. The program was developed by the Missouri Department of Health and Senior Services with endorsement from SEMA and the American Red Cross.

Show-Me Response—is the online registration system for health professionals to volunteer to provide services during a disaster or emergency situation.

Department of Higher Education

At the direction of the Coordinating Board for Higher Education (CBHE), the Missouri Department of Higher Education (MDHE) strives to coordinate higher education policy that fosters a quality postsecondary system, as well as increase participation in Missouri's public institutions. The State system of higher education serves more than 620,632 000 students attending Title IV post-secondary institutions in the State of Missouri. There are 13 public four-year universities, 13 degree-granting public colleges, one state technical college, 54 non-for-profit four year and above institutions, and more than 140 proprietary and private career schools. .The MDHE convenes meetings of the Higher Education Subcommittee of the Homeland Security Advisory Council approximately five times per year as a pre-disaster initiative. The role of this group is to promote pre and post disaster emergency planning initiatives on all higher education campuses in Missouri, share best practices, and ensure that collegiate institutions throughout the State are informed about and engaged in emergency planning. To this end, the Higher Education Subcommittee maintains a list of campus liaisons for coordination of statewide emergency and homeland security operations. All public and independent Missouri institutions of higher education are members of the Missouri Alert Network, which ensures that each campus will receive a message from state officials within a few minutes if an extraordinary situation occurs impacting security and safety. The Higher Education Subcommittee is also working with institutions in reviewing and adapting the Emergency Response Information Program (ERIP) web-based tool to develop campus emergency response and all-hazard plans. Institutions can also provide tactical response information to community first responders using the ERIP system.

Department of Insurance, Financial Institutions, and Professional Registration

The Department of Insurance, Financial Institutions, and Professional Registration has resources for insurance customers, companies, and producers. The department is capable to promote flood and earthquake insurance as a pre-mitigation measure.

Mitigation-Related Programs and Planning

The Department enforces *RSMo 379.975,* which requires insurers to provide information to applicants and policyholders about earthquake insurance for properties located in the New Madrid Seismic Zone (that is susceptible to Modified Mercalli intensity VII or above earthquake), and *RSMo 379.978,* which requires all insurance companies that provide earthquake coverage to prepare a written disaster plan that addresses earthquakes.

Section 207 of the Flood Insurance Reform Act of 2004 requires all producers selling policies under the NFIP to be properly trained and educated about the NFIP to ensure that clients are better served. The federal law directs the Department of Insurance to require producers to complete a one-time NFIP course which provides continuing education credit to those insurance agents. Additionally, this department suggests that insurance producers advise their clients of the availability of flood insurance coverage.

Department of Labor and Industrial Relations

The Department of Labor and Industrial Relations is responsible for administering programs that provide payment of unemployment insurance benefits to workers who become unemployed through no fault of their own.

When a Missouri county or region is impacted by a natural disaster or hazardous condition such as flooding or inclement weather, the Labor Department has the authority to suspend in-person reporting required of the unemployed for a period of time. This helps to assist in the post-disaster recovery of the local communities. The Labor Department is capable with the support of other state and/or other government agencies, of providing fairly prompt unemployment insurance benefits to workers in disaster-affected areas.

Department of Mental Health

The Department of Mental Health (DMH) maintains an All-Hazard Emergency Operations Plan as a pre-disaster measure. The plan, developed with the input of the Mental Health Statewide Disaster Response Planning Committee, is designed to enhance department planning and response activities and minimizes the effects of disasters (natural, manmade or other) on DMH consumers and the residents of Missouri. The Department also ensures the DMH facilities maintain and exercise facility emergency operations plans; provide education and training for people with special needs, schools, healthcare workers, and other first responders to mitigate the emotional impacts of disaster events; and maintains a Continuity of Operations Plan and a Pandemic Flu annex to help mitigate against the effects of displacement.

Mitigation-Related Programs and Planning

All-Hazards Emergency Operations Plan, dated December 2012—this plan was developed with the input from the Mental Health Statewide Disaster Response Planning Committee. It was designed to enhance department planning and response activities in order to minimize the efforts of disaster or terrorism on DMH clients, the communities and the citizens of Missouri.

Mental Health Disaster Communication Guidebooks—the department of Mental Health partnered with DHSS to develop a public education program on emotional preparedness for any event Missourians may face that included talking points to help promote emotional well-being and greater coping skills for those facing the negative effects of a disaster.

Department of Natural Resources

The Department of Natural Resources (DNR) protects, preserves, and enhances Missouri's natural, cultural, and energy resources. DNR includes the divisions of Environmental Quality, Geology and Land Survey, State Parks, Environmental Improvement and Energy Resources Authority, and the Office of the Director, which houses the Energy Center, Water Resources Center (i.e. Dam and Reservoir Safety) and the Soil and Water Conservation Program. The department administers various projects designed to reduce stream bank erosion, reduce localized flooding, improve drainage, reduce discharge, improve water quality, ensure safe drinking water, and make sure that dams are constructed, maintained, and operated in a safe manner. The Water Resources Center has a mission to maintain the quantity of Missouri's water resources and administers the State Water Plan. The Water Protection Program provides for an adequate supply of safe drinking water to the citizens of Missouri and the protection of bodies of water within the State.

The DNR's Division of Geology and Land Survey (DGLS) is housed at the Rolla campus at 111 Fairgrounds Road, Rolla, MO 65401. As well as DGLS, the Rolla Campus houses the Water Resources Center, Dam Safety and a satellite office for the Division of Environmental Quality. DGLS has many multi-disciplined geoscientists, engineers and technical professionals to assist in providing professional and technical advice to state and local emergency managers and other state and local officials. Most of the of the Division's professional and technical staff hold certifications in various emergency response functions and can assist others. DGLS provides technical assistance, education, and guidance in the use and protection of Missouri's natural resources, interprets the State's geological settings and resource potential, evaluates and interprets geological hazards and houses the State's land survey records.

DGLS has developed and maintains an Earthquake Emergency Response Plan which includes emergency response capabilities and hosting Missouri's Post-Earthquake Technical Information Clearing House (PETIC) at the Rolla Campus. The PETIC will serve as a control for gathering/dissemination of scientific information as well as credentialed geoscientists/engineers into and out of the affected area. The PETIC will operate under the direct guidance of the State Geologist which is part of the Emergency Response Support Function 5 (SF-5, Operations) to assist SEMA's response to an earthquake or to support other requests.

DGLS is actively pursuing and participating in Education and Outreach (E&O) opportunities throughout the State targeting earthquake awareness and environmental stewardship. DGLS participates in Earthquake Awareness Month conducting workshops and seminars with SEMA, the Central United States Earthquake Consortium (CUSEC), CUSEC State Geologists (CUSEC SG) and other public and private institutions to promote earthquake mitigation and education.

The State Historic Preservation Office (SHPO) is in the department's Division of State Parks. The SHPO, in coordination with SEMA, performs historic preservation reviews of proposed FEMA-funded mitigation projects.

Mitigation-Related Programs and Planning

Dam and Reservoir Safety Program—the Missouri Dam and Safety Reservoir Law of 1979 established a dam safety program in the Missouri Department of Natural Resources to ensure that dams in the State are constructed, maintained, and operated in a safe manner. This is accomplished by regulation of all nonagricultural, nonfederal dams 35 feet or more in height and by providing technical assistance and informational resources to all dam owners. The law also established a Dam and Reservoir Safety Council, whose has the responsibility to adopt and amend standard and technological guidelines and to adopt and amend rules and regulations applicable to permits, design, construction, maintenance, operation, alteration, repair, reduction, removal, and natural physical changes to any dam or reservoir. The Department of Natural Resources has analyzed and produced 370 dam inundation maps in the Stat of Missouri. The Department of Natural Resources coordinates with SEMA when problems develop with a dam. If a problem occurs after hours or on a weekend, SEMA's duty officer is notified. The SEMA duty officer responds as appropriate to the situation according to a manual of procedures.

Central United States Earthquake Consortium—Since 1983, Arkansas, Illinois, Indiana, Kentucky, Mississippi, Missouri, and Tennessee have been members of the Central United States Earthquake Consortium (CUSEC), which was formed to improve public earthquake awareness and education; coordinate multi-state mitigation planning for earthquakes, preparedness, response and recovery; and to encourage research in earthquake hazard reduction. The earthquake program managers and state emergency management directors of the member states meet at least twice annually with CUSEC management and FEMA's regional earthquake program managers to formulate earthquake safety and mitigation programs and projects.

Missouri Drought Response Plan, dated 2002—updated by DNR's Water Resources Division in 2002. The purpose of the plan is to address the need for coordinated advanced emergency planning. It complements and supports the State Emergency Operations Plan. The current version reflects the lessons learned in responding to the drought of 1999–2000. It also divides the State into three drought management areas according to their susceptibility to drought: slight, moderate, or high.

Missouri Water Supply Study, Amended 2009—to ensure availability of water information for effective decision making by communities and the Missouri Department of Natural Resources Water Resources Center. The scope of the study addresses surface water supplies for cities and communities that are expected to experience water shortages during an extended drought. In 2005, it analyzed 34 communities' water systems and the 2009 version includes several more. The Missouri Drought Assessment Committee developed this plan based on the State's Water Resources Law.

State Water Plan—is a directive by Missouri statutory law to "develop, maintain and periodically update a state water plan for a long-range, comprehensive statewide program for the use of surface water and groundwater resources of the State, including existing and future needs for drinking water supplies, agriculture, industry, recreation, environmental protection and related needs." The State Water Plan has two phases. Phase I includes a series of seven technical assessment documents to provide basic information about Missouri's streams and rivers, groundwater, water use, water quality, interstate water issues, hydrologic extremes, and water law. Phase II identifies regional problems and opportunities related to water use. The regions are keyed to the department's historic regional office service areas. State Water Plan staff have helped raise awareness of Missouri River issues by sponsoring five Missouri River Constituency Conferences. Staff also analyzed the impacts of the 1993 floods in the document *Flood Report Analysis* (1996). The State Water Plan Inter-Agency Task Force (IATF) was

established by state statute-640.430 RSMo to advise the Department of Natural Resources on a wide variety of water quantity and quality related issues for the purpose of effectuating aims and purposes of the Missouri Water Resources Law.

Stormwater Improvements Program—In 2001, the Missouri Department of Natural Resources awarded more than $9.9 million to 46 Missouri communities for stormwater improvements. Of these 46 communities, 7 had populations of 3,000 or less. Funding for these grants came from bond issues approved by Missouri voters in 1998 for improvements to stormwater, wastewater treatment, and public drinking water systems. The last bond sale occurred in 2002. The types of projects approved included developing city and county stormwater management plans, replacing undersized drainage systems, buying and demolishing flood-prone homes, and implementing structural measures to alleviate erosion and prevent future channel degradation.

Department of Public Safety

The Department of Public Safety is comprised of the Office of Homeland Security, and the divisions of the Missouri State Highway Patrol, Missouri State Water Patrol, State Emergency Management Agency, Missouri National Guard-Office of the Adjutant General, Division of Fire Safety, Capitol Police, Division of Alcohol and Tobacco Control, Missouri Veterans Commission, and Missouri Gaming Commission.

The Department's desired outcomes that are specific to mitigation efforts are: to mitigate the threat of terrorism; reduce preventable injuries and fatalities; interoperable communications for law enforcement and emergency services; increase crime prevention; and to improve the ability to respond and provide recovery from all "hazard events".

DPS, Division of Fire Safety

The Division of Fire Safety and the State Fire Marshal provide fire and life safety enforcement and education to all residents so they receive the highest quality of service to ensure safety and a sense of wellbeing. The State Fire Marshal provides post disaster assistance to local jurisdictions through Incident Support Teams and this initiative provides experienced command level personnel to assist in local Emergency Operation Centers (EOC).

DPS, Office of Homeland Security

In Missouri, "homeland security" covers all of the public safety missions ranging from law enforcement, fire service, and first-responders, to emergency preparation, management, training and mitigation.
Homeland Security is also the responsibility of every citizen in our nation and state. It needs an informed and prepared citizenry to help Homeland Security do their jobs.

DPS, State Highway Patrol

The Missouri State Highway Patrol enforces traffic laws and promotes safety on the highways. The State Highway Patrol provides all officers with training on weapons of mass destruction and gives additional terrorism training to sergeants and staff officers. They establish and maintain communications with all local police and sheriff departments, particular during and after natural disaster events. There are also four special emergency response teams located throughout the State that are available to assist at all times.

Mitigation-Related Programs and Planning

Missouri Division of Fire Safety Strategic Plan, Revised 2005—sets goals, objectives, and strategic actions for reducing danger from fires and explosions.

Missouri Systems Concept of Operational Planning for Emergencies (MoSCOPE), dated 2008—started as a grant from the International Association of Fire Chiefs (IAFC) to the Missouri Association of Fire Chiefs (MoChiefs) to review and revise Missouri's Fire Mutual Aid program and produce a mutual aid template capable of being used by any responder discipline. This revision was completed in 2008 and was called MoSCOPE (Missouri Systems Concept of Operational Planning for Emergencies). In conjunction with the Division of Fire Safety, regional mutual aid coordinators and MoChiefs, IAFC held a tabletop exercise in October of 2008 to evaluate and validate the revised Fire Mutual Aid program based upon MoSCOPE. The exercise was successfully completed and the revised template validated for use.
To assist with this mutual aid template, the Division obtained funding for a part time statewide fire mutual aid coordinator. This position is tasked with further development of the Statewide Mutual Aid program to assist other responder disciplines in establishment of their own mutual aid systems.

Missouri Homeland Security Alert Network—provides Missouri public safety officials with immediate phone, email and text message broadcast capabilities to the key individuals within each participating stakeholder community. By utilizing this network, public safety, health, and other officials will be able to instantly message up to 5,000 elected and appointed leaders in individual first responder and other stakeholder communities such as police, sheriff's, fire departments, county and city government, emergency medical services (EMS), 9-1-1 Centers, and even key private sector stakeholders. The system allows a message to be sent to just one discipline or community of stakeholders, or to everyone. A message can also be sent to a selected geographic area, or the whole state.

Department of Social Services

The Department of Social Services (DSS) is the lead state agency responsible for coordinating mass care activities during disaster events. Mass care activities primarily include coordination of sheltering for general populations, and food, water and bulk distribution coordination in affected areas in partnership with the American Red Cross, the Salvation Army, other non-governmental or volunteer organizations and other state agencies. DSS employees respond to the State Emergency Operations Center to staff the Emergency Support Function 6 (ESF 6) desk during disaster events. DSS employees have also been assigned to respond to the two State Area Coordination Centers as needed. DSS County Managers participate in local emergency planning activities. They immediately contact their local Emergency Management Directors during an emergency event and provide assistance if needed. On-going training is provided to all staffing levels to prepare for mass care responsibilities. Field staff provide daily reporting of local emergency management activities, i.e., shelter operations status, shelter locations, number of residents, special requests, etc. Field staff participate in Multi Agency Resource Centers following disaster events. DSS participates in exercises and exercise planning with SEMA and other state and federal agencies as well as other partners in an effort to be as prepared as possible to respond adequately and appropriately when a disaster event occurs.

Mitigation-Related Programs and Planning

Emergency Operations Plan, Children's Division, dated 2008—designed to help DSS, Children's Division respond in all four phases of emergency management by providing all services needed by the children and families they serve.

Department of Transportation

The Department of Transportation (MoDOT) is a key responder in most emergencies and disasters in the State of Missouri. The primary MoDOT mission as it relates to emergencies and disasters is to "get the roads open." During a response effort, MoDOT uses all of its resources including thousands of field staff and related equipment, administrative personnel and other personnel to manage emergency events and works in coordination with other emergency response agencies. MoDOT maintains a Traveler Information Map at www.MoDOT.org that provides real time information on road conditions, incidents and work zones. MoDOT also has traffic management systems in place that manage all of the urban and rural interstate highways and some other routes. These systems include 24/7 Traffic Management Centers in St. Louis and Kansas City, 24/7 emergency response crews around the State and field devices such as video cameras electronic message signs, weather stations and traffic detectors. At the same MoDOT also provides a key coordination role with general aviation airports, public transit, waterway ports and railroads.

MoDOT personnel provide technical assistance to various emergency management programs, including mitigation. This assistance is addressed in the SEMA-MoDOT Memorandum of Agreement and includes environmental reviews and archaeological surveys for projects funded through the HMGP and PDM grants. MoDOT and SEMA collaborate on earthquake mitigation and coordinate buyout projects to ensure that there are no potential right-of-way conflicts with future use of land for bridge and highway projects. In addition, MoDOT incorporates flood and earthquake standards into new bridge designs and is working on a database that identifies which Missouri bridges have been constructed or retrofitted to earthquake design standards. MoDOT also works on major river bridge projects and wetland reestablishment and rehabilitation. The agency also enforces hazardous materials regulations and manages the registration and licensing of carriers who haul hazardous waste through the State. HazMat response coordinators from the 10 districts work with the DNR on spill response.

Mitigation-Related Programs and Planning

Statewide Transportation Improvement Program, 2008–2014—identifies all transportation projects planned by state and regional planning agencies for fiscal years 2008 through 2014. The program includes projects for highways, bridges, transit, aviation, rail, waterways, and other projects. It is a project-specific document that tells Missourians what improvements to expect on their transportation system during this period. Projects must consider mitigation against hazards, specifically relating to flooding and earthquakes. This five-year plan is updated each year, and as one year of work is completed, a fifth year of new projects is added.

Office of Administration

The Office of Administration enforces floodplain management regulations for state facilities. The Office of Administration's Division of Design and Construction manages the State's facilities program. It selects consulting architectural and engineering firms for capital improvements projects, administers the construction program, and assists agencies in preparing their capital improvement budget requests.

Mitigation-Related Programs and Planning

The Office of Administration is conducting an on-going program to geolocate facilities that the State owns and/or leases. This can allow the State Hazard Mitigation Plan to refine the hazard risks on those State facilities.

Public Service Commission

The Missouri Public Service Commission (PSC) regulates investor-owned public utilities operating in Missouri that can be affected by disaster events. The PSC has the statutory responsibility for ensuring that customers receive adequate amounts of safely delivered and reasonably priced utility services at rates that will provide the companies' shareholders with the opportunity to earn a reasonable return on their investments. The PSC must balance a variety of often competing private interests to ensure the overall public interest.

Mitigation-Related Programs and Planning

Missouri Energy Task Force Action Plan, implemented 2006—it described ideas and actions to maintain, upgrade and expand the existing utility infrastructure to improve reliability.

Federal Agency Mitigation-Related Programs and Planning

U.S. Geological Survey St. Louis Earthquake Hazard Mapping Project—Researchers at the Missouri University of Science & Technology; Saint Louis University; Missouri Department of Natural Resources; Illinois Geological Survey; Central United States Earthquake Consortium; and the U.S. Geological Survey (USGS) are collaborating to compile subsurface geologic data and to conduct high-resolution seismic imaging investigations at over 100 locations in the St. Louis metropolitan area. This data will help to better characterize earthquake hazards and ground motion in this region. Urban seismic hazard maps differ from the USGS national seismic hazard maps in that they are higher resolution and account for the effects of the shallow rocks, sediments, and topography on earthquake ground shaking (i.e., site effects).

National Oceanic and Atmospheric Administration StormReady Program—is a voluntary program that was developed by the National Oceanic and Atmospheric Administration's (NOAA) National Weather Service (NWS) to help communities better prepare for and mitigate effects of extreme weather-related events. StormReady also helps establish a commitment to creating an infrastructure and systems that will save lives and protect property. Receiving StormReady recognition does not mean that a community is storm-proof, but StormReady communities will be better prepared when severe weather strikes.

For each community, preparedness criteria are outlined by a partnership between the NWS and state and local emergency managers. At a minimum, communities must establish a 24-hour warning point and emergency operations center; have more than one method of receiving severe weather forecasts and warnings and alerting the public; create a system that monitors local weather conditions; promote the significance of public readiness through community seminars; and develop a formal hazardous weather plan. As of May 28. 2013, Missouri had 20 counties, 41 communities, two commercial sites, and four universities that are recognized as StormReady.

National Oceanic and Atmospheric Administration Weather Radio All Hazards—are tone alert radios that provide continuous weather coverage and can be programmed to sound when severe weather watches, warnings, or other critical information is broadcast by the National Weather Service. Due to the joint efforts of many electric cooperatives, private businesses, the National Weather Service, FEMA, and SEMA, every county in the State is covered by a NOAA Weather Radio transmitter providing over 95 percent coverage (hills and terrain cause blockage to a strong signal is some areas). The coverage benefits everyone by providing early warnings for severe weather events and giving people extra time to

protect their families and property. This effort is a public-private partnership that uses mostly private, donated tower space for the transmitters.

4.2.2 Policies and Regulations

There are currently no state laws, codes, or regulations that specifically address the topic of hazard mitigation. With a few exceptions, such as local floodplain management ordinances, local governments in Missouri have generally been opposed to establishing mitigation-related codes and standards. This continues to be an area of hesitation to implement government-mandated mitigation-related codes, statutes, or regulations in many areas of the State. But other programs such as public education and voluntary initiates are successfully implemented at both the State and local level. The State has several statutes that address hazard mitigation through the creation of special councils or committees and rules and requirements for agencies and local governments to follow. These primarily address seismic hazards, floodplain management, water resources, dam and reservoir safety, as well as public health emergencies. Table 4.2.2a summarizes the statutes and executive orders that enhance the State's capabilities to reduce the impacts of future disasters. There are no new policies or changes since the adoption of the previous plan update that have affected hazard mitigation capabilities.

Table 4.2.2a Missouri State Policies Related to Hazard Mitigation

Policy	Requirements
RSMo 44.020: State Emergency Management Agency created	There is hereby created within the military division of the executive department, office of the adjutant general, the "State Emergency Management Agency," for the general purpose of assisting in coordination of national, state, and local activities related to emergency functions by coordinating response, recovery, planning and mitigation. This agency shall also serve as the statewide coordinator for activities associated with the National Flood Insurance Program.
RSMo 44.028: State may accept federal goods and services on behalf of itself and its subdivisions	Whenever the federal government or officer or agency thereof shall offer to the State, or through the State to any political subdivision thereof, services, equipment, supplies, materials or funds by way of gift, grant or loan, for the purpose of emergency management, the State acting through the agency, or the political subdivision, through its executive officer with the consent of the governor, may accept the offer and may receive these services, equipment, supplies, materials or funds on behalf of the State or the political subdivision subject to the terms of the offer.
RSMo 44.032: Emergency powers of governor, uses—Missouri disaster fund, funding, expenditures, procedures, purposes—aid to political subdivisions, when, procedure—expenditures in excess of $1,000, governor to approve	There is hereby established a fund to be known as the "Missouri Disaster Fund," to which the general assembly may appropriate funds and from which funds may be appropriated annually to the State emergency management agency. The funds appropriated shall be expended during a state emergency at the direction of the governor and upon the issuance of an emergency declaration which shall set forth the emergency and shall state that it requires the expenditure of public funds to furnish immediate aid and relief. The director of the state emergency management agency shall administer the fund. Expenditures may be made upon direction of the governor for emergency management, as defined in section 44.010, or to implement the state disaster plans. Expenditures may also be made to meet the matching requirements of state and federal agencies for any applicable assistance programs.

Policy	Requirements
RSMo 44.080: All political subdivisions shall establish a local emergency management organization	Each political subdivision of this state shall establish a local organization for disaster planning in accordance with the state emergency operations plan and program.
RSMo 49.600: National flood insurance program, adoption and rescission procedure-exemptions (certain second-, third- fourth-class counties)	The county commission, in all counties which have not adopted county planning and zoning, may adopt or rescind by order or ordinance regulations to require compliance with FEMA standards, necessary to comply with the National Flood Insurance Program, in any flood hazard area designated by FEMA; provided, however, that no ordinance or order enacted pursuant to this section in any county shall be effective unless the county commission or governing body of the county submits to the voters of a county a proposal to authorize the county commission or governing body of the county to adopt such an order or ordinance.
RSMo 49.605: Permits, authorized requirements for applicant	No permit required by the provisions of order or ordinance regulations adopted pursuant to the provisions of sections 49.600 to 49.615 shall be denied an applicant if the proposed construction, use or other development will not raise the flood elevation of the 100-year flood level more than one foot; provided, however, that any permit may require that the lowest floor of an insurable structure shall be above the 100-year flood level and that all structures shall be adequately anchored to prevent flotation, collapse, or lateral movement of the structure.
RSMo 49.610: Variances may be granted by county commission, when	Any order or ordinance regulations adopted pursuant to sections 49.600 to 49.615 shall provide that the county commission may grant individual variances beyond the limitations prescribed by the order or ordinance regulations upon presentation of adequate proof that compliance with the provisions will result in an exceptional hardship to applicant or any arbitrary and unreasonable closing or prevention of any lawful construction, use, or other development in the area or county and which will not result in additional threats to public safety and will not be inconsistent with the objectives of sound floodplain management.
RSMo 700.015: Code compliance required, when—seal required—exemptions from code requirements for sale of new recreational vehicles and park trailers	No person shall rent, lease, sell, or offer for sale any new manufactured home manufactured after January 1, 1974, unless such manufactured home complies with the code and bears the proper seal. No person shall manufacture in this state any manufactured home or modular unit for rent, lease or sale within the State which does not bear a seal evidencing compliance with the code. No person shall offer for rent, lease or sale a new modular unit or a unit used for educational purposes manufactured after January 1, 1974, unless such modular unit complies with the code and bears a seal issued by the commission evidencing compliance with the code.
RSMo 700.065: Manufactured homes to be anchored	All manufactured homes located in this state shall be anchored and tied down in accordance with the standards promulgated by the commission.
RSMo 44.227-237: Commission on seismic safety created	Authorizes creation, duties, and powers of the Missouri Seismic Safety Commission, as well as gives the commission responsibilities to undertake a study to determine the feasibility of establishing a comprehensive program of earthquake hazard reduction to save lives and mitigate damage to property in Missouri.
RSMo 160.451: Earthquake emergency system to be established for certain school districts	The governing body of each school district which can be expected to experience an intensity of ground shaking equivalent to a Modified Mercalli of VII or above from an earthquake occurring along the New Madrid Fault with a potential magnitude of 7.6 on the Richter Scale shall establish an earthquake emergency procedure system in every school building under its jurisdiction.

Policy	Requirements
RSMo 160.453: Requirements for emergency system—public inspection of system authorized	This earthquake emergency system shall include 1) A school building disaster plan; 2) An emergency exercise to be held at least twice each school year; 3) Protective measures to be taken before, during, and following an earthquake; and 4) A program to ensure that the students and certified and noncertified employees of the school district are aware of, and properly trained in, the earthquake emergency procedure system.
RSMo 160.455: Distribution to each student certain materials on earthquake safety— duties of school district	At the beginning of each school year, each school district shall distribute to each student materials that have been prepared by the Federal Emergency Management Agency, SEMA, or by agencies that are authorities in the area of earthquake safety and that provide the following objectives: 1) Developing public awareness regarding the causes of earthquakes, the forces and effects of earthquakes, and the need for school and community action in coping with earthquake hazards; 2) Promoting understanding of the impact of earthquakes on natural features and manmade structures; and 3) Explaining what safety measures should be taken by individuals and households prior to, during and following an earthquake.
RSMo 256.173: Cities and counties to be furnished geologic hazard assessment prepared by Division of Geology and Land Survey	The Division of Geology and Land Survey in the Missouri Department of Natural Resources shall provide each county as the information becomes available a geologic hazard assessment and assistance in the use and application of the geologic hazard assessments, which will be made available to the public. The Department of Natural Resources shall provide each recorder of deeds of each county in the State a map showing the downstream area that would be affected in the event of a dam failure.
RSMo 256.175: High seismic risk area data-duties of department	The Missouri Department of Natural Resources shall furnish to SEMA technical data, including soil liquefaction and seismic effects, on structural foundations that are located in a high seismic risk area. If requested by a local government entity, the department shall assist in the establishment of construction standards based on the data provided in this subsection. The Department shall be designated as the lead technical agency in the State to conduct studies concerning the geologic effects of earthquakes.
RSMo 319.200-207: Notice to cities and counties subject to earthquake to adopt seismic construction and renovation ordinances, when-standards	Each city, town, village, or county that can be expected to experience an intensity of ground shaking equivalent to a Modified Mercalli of VII or above from an earthquake occurring along the New Madrid Fault with a potential magnitude of 7.6 on the Richter Scale, shall adopt an ordinance or order requiring that new construction, additions and alterations comply with the standards for seismic design and construction of the building officials and code administrators code or of the uniform building code. Cities and counties found not to comply with the requirements of sections 319.200 to 319.207 shall not be eligible to receive any state aid, assistance, grant, loan or reimbursement until compliance has been proven to the satisfaction of the commissioner of administration.
RSMo 379.975: Insurer to provide information on earthquake insurance	for coverage on property located in the New Madrid Seismic Zone, as defined by the United States Geological Survey in Missouri, susceptible to Modified Mercalli intensity VII or above from an earthquake occurring along the New Madrid Fault with a potential magnitude of 7.6 on the Richter scale, the insurer shall provide information to the applicant or policyholder regarding the availability of insurance for loss caused by earthquake.
RSMo 379.978: Written disaster plan, insurer to develop, contents	Every insurance company that insures property for loss caused by earthquake shall prepare and retain a written disaster plan covering earthquakes. This plan shall include specific provisions regarding procedures for handling claims under the insurance company's issued policies or endorsements covering loss or damage from the peril of earthquake.

Policy	Requirements
RSMo 640.412: Inventory to be maintained on ground and surface water uses, quantity, and users	The Department of Natural Resources shall inventory 1) existing surface water and groundwater uses; 2) the quantity of surface water and groundwater available for uses in the future; and 3) water extraction and use patterns, including regulated and unregulated users.
RSMo 640.415: State water resource plan to be established for use of surface and ground water—annual report, contents—powers of department	Authorizes the Department of Natural Resources to develop, maintain, and periodically update a state water plan for a long-range, comprehensive statewide program for the use of surface water and groundwater resources of the State, including existing and future need for drinking water supplies, agriculture, industry, recreation, environmental protection, and related needs. This plan shall be known as the "State Water Resources Plan". The department shall collect data, make surveys, investigations and recommendations concerning the water resources of the State as related to its social, economic and environmental needs.
RSMo 644.018: Reasonable use defined in cases involving surface water in flood-prone areas	In any contested case or judicial proceeding filed after January 1, 1998, involving surface water in any flood-prone area, if any defendant has obtained and fully complied with a permit from a political subdivision which has enacted orders or ordinances as required by FEMA as a prerequisite to participation in the National Flood Insurance Program, and which political subdivision has jurisdiction, pursuant to the zoning laws of this state or the laws and regulations of FEMA, over the area in dispute, then the proper permitting and compliance with all conditions of such permitting of such project shall be conclusive proof that the project is a reasonable use and meets any reasonable-use test imposed by law or by a court.
RSMo 236.400-425: Dam and Reservoir Safety Program and Council established	Creates a dam and reservoir safety program and "Dam and Reservoir Safety Council" in the Department of Natural Resources. The council shall consist of seven members, no more than four of whom shall be members of the same political party, appointed by the governor with the advice and consent of the senate. The council shall promulgate rules, regulations, guidelines, and standards relating to the determination of whether a dam or reservoir constitutes a danger to public safety, life or property to be effective upon approval by the director. The council, with the advice and assistance of the chief engineer, shall carry out a state program of inspection of dams and reservoirs in accordance with regulations adopted by the council. All dams and reservoirs in this state shall be inspected on a periodic basis to determine if they constitute a threat to public safety, life or property. Also authorizes the director of the Department of Natural Resources to appoint a chief engineer, who shall submit reports to the director and the council concerning the condition of each dam or reservoir inspected, and recommendations as to any alterations or repairs needed.
RSMo 245.015: Owners may form levee district, where—articles of incorporation to be filed in circuit court	The owners of a majority of the acreage in any contiguous body of swamp, wet or overflowed land or other property in the nature of individual or corporate franchises in this state, or land subject to overflow, wash or bank erosion, located in one or more counties or in any city, town, or village in this state not located within any county with a charter form of government and with more than two hundred fifty thousand but less than three hundred fifty thousand inhabitants, or in any city, town, or village of the third or fourth classification in this state which is located within any county with a charter form of government and with more than two hundred fifty thousand but less than three hundred fifty thousand inhabitants, may form a levee district for the purpose of having such land and other property reclaimed and protected from the effects of overflow and other water, for sanitary or agricultural purposes, or from the effect of wash or bank erosion, or when the same may be conducive to the public health, convenience or welfare, or of public utility or benefit, by levee, or otherwise.

Policy	Requirements
RSMo 254.270. Fire control and timber trespass activities intensified, when—provisions for added protection	Fire control and timber trespass activities will be intensified and may be extended to include all woodlands in the State as deemed in need of such protection by the commission within the limits of funds provided. Any person whether or not his lands are classified as forest croplands may receive such assistance. Any owner may make application to the commission for special attention in forest fire control requiring expenditures in excess of those permitted within the limits of funds provided for general activities under this chapter, by subscribing a payment of not less than three cents per acre per year for such added protection as the commission may deem advisable and desirable.
RSMo 236.455: Emergency Action Authorized	If it is determined at any time that the condition of a dam or reservoir is an imminent and substantial threat, and so dangerous to public safety, life, or property as not to permit time for issuance of an enforcement order to correct the hazard, the chief engineer may take any appropriate action not prohibited by the constitution or laws of this state he deems necessary for emergency protection of public safety, life or property, and may request the attorney general or a prosecuting attorney to take any legal steps necessary to accomplish such action and to recover the cost of such measures from the owner by appropriate legal action.
RSMo 640.130: Emergencies—actions to be taken—water systems in violation, penalties	Whenever the Department of Natural Resources determines that an emergency exists which endangers or could be expected to endanger the public health and safety with regard to drinking water supplies, the department may, without notice or hearing, issue an order reciting the existence of such a condition and requiring the person to take such action as will lessen or abate the danger. At the request of the department, the attorney general may bring an injunctive action or other appropriate action in the name of the people of the State Whenever the department determines that a public water system is in violation … it may issue an administrative order requiring the public water system to comply with such rule or statute.
RSMo 640.140: Department may cooperate with others—may receive aid, conduct training and research—may financially assist in construction of water systems	The Department of Natural Resources may enter into agreements, contracts, or cooperative arrangements under appropriate terms and conditions with other state agencies, federal agencies, interstate agencies, political subdivisions, educational institutions, local health departments, or other organizations or individuals for the purpose of administering the State drinking water supply program. The department may solicit and receive grants of money or other aid from federal and other public or private agencies or individuals … to conduct research and training activities or cause them to be conducted, to financially assist in the construction of water works systems or portions thereof, or for other program purposes.
RSMo 319-500: Pipelines transporting hazardous liquids to submit periodic reports to department of natural resources—content	Any owner or operator of pipelines transporting hazardous liquids, as defined in the federal Hazardous Liquid Pipeline Safety Act of 1979, 49 USC 2001, et seq., shall submit periodic reports to the department of natural resources as required by the director of the department of natural resources under this section.
RSMo 44.090: Repealed in 2009 & new section enacted for Missouri's mutual aid system	The Missouri mutual aid system shall be administered by the department of public safety, which may authorize any organization to assist in the administration of the mutual aid system.
19 CRS 20-20.020	Missouri disease reporting requirement to DHSS.
Executive Order 82-19, 1982	Potential effects of actions taken in a floodplain should be evaluated to avoid adverse impacts.

Policy	Requirements
Executive Order 93-40, 1993	Establishes the Task Force on Flood Plain Management and the composition of its members. The task force reviews and makes recommendations on 1) the building, rebuilding, or relocation of levees; 2) state highway and road projects in floodplains; and 3) expenditures of public funds for projects in floodplains which require state action or approval. The task force will make recommendations to the governor regarding proposed legislation and long-term policy regarding development of housing and other private and public structures in floodplain areas.
Executive Order 94-25, 1994	Establishes the Disaster Recovery Partnership to review and design new human services disaster response and recovery delivery methods, establish more rapid and complete communications to disaster victims and caregivers, and promote, train, and support local committees.
Executive Order 97-09, 1997	Authorizes SEMA to issue floodplain development permits for any state owned or leased development in a special flood hazard area.
Executive Order 03-23, 2003	Reaffirms the endeavors of the Disaster Recovery Partnership and ascribes to it the additional functions of a state citizen council.
Executive Order 05-20, 2005	Establishes the Missouri Homeland Security Advisory Council to review and evaluate current state and local homeland security plans and make recommendations for changes to better protect Missourians and to review requests and provide recommendations on the appropriate use of Homeland Security grant funds from the federal government. Creates the Division of Homeland Security within the Department of Public Safety to coordinate activities to promote unity of effort among federal, state, local, private sector, and citizen activities related to emergency preparedness and homeland security.
Executive Order 06-10, 2006	Creates the Citizen Corps to help coordinate volunteer and individual or family preparedness activities in any emergency situation.
Executive Order 06-41, 2006	Creates the Interdepartmental Coordination Council for Water Quality.
Executive Order 09-25, 2009	Creates and establishes the Governor's Faith-Based and Community Service Partnership for Disaster Recovery. It is comprised of governmental and private agency representatives.

4.2.3 Development in Hazard-Prone Areas

Missouri is a "home-rule" state and does not have a statewide program for land use or a statewide building code; however, the State does address development in seismic and flood hazard areas. State statutes require that new public construction, additions, and alterations comply with certain standards for seismic design and construction if located in areas subject to a certain level of ground shaking. It is up to local governments to implement and enforce the use of building codes. SEMA emphasizes the use of building codes at mitigation training programs and when briefing new state legislators.

As a result of a 1997 executive order, SEMA issues floodplain development permits for any state-owned or leased development in a SFHA. Local governments participating in the NFIP address development in flood hazard areas through their floodplain management ordinances. In addition, through the Community Buyout Program, the State works with local communities to voluntarily relocate structures out of flood-prone areas. The Missouri Department of Transportation and SEMA coordinate buyout projects to ensure that there are no potential right-of-way conflicts with future use of land for bridge and highway projects. The Community Buyout Program continues to be an effective tool in removing

existing property from the floodplain and preventing future losses in floodplains, as demonstrated in Section 7.5 Effective Use of Available Mitigation Funding. During the 2013 update, the evaluation of the Community Buyout Program identified some challenges and shortfalls. These are noted in Section 4.2.6 Implementation Opportunities and Challenges.

4.2.4 Funding Capability

The majority of funding for hazard mitigation projects is attained through federal programs. More information on these funding sources is provided in Section 4.5 Funding Sources. The State's funding capabilities for mitigation projects include partial funding of the floodplain management budget, the DNR Stormwater Grant Program, and SEMA's operating budget, which helps support mitigation programs and staff:

- Funding for floodplain management has increased from $14.9 million in 2009 to $17.2 million 2012.
- In the past, some Missouri local communities have approved bond measures to provide grant funding for improvements to stormwater, wastewater treatment, and public drinking water systems through the Missouri Department of Natural Resources' Stormwater Grant Program.
- SEMA's funding sources for operating expenses in fiscal year 2012 consisted of 82.8 percent from federal sources, 9.9 percent from general revenue, and 0.7 percent from other funds. Funding for SEMA through general revenue and other funds was approximately $17.2 million.

Section 44.032 of the Missouri Revised Statutes establishes the Missouri Disaster Fund to "furnish immediate aid and relief." The fund is primarily for response and recovery costs, but the section states that "provisions of this section shall be liberally construed in order to accomplish the purposes of sections 44.010 to 44.130. Section 44.010 defines emergency management functions, emergency management activities, and emergency management service as "those functions required to prepare for and carry out actions to prevent, minimize and repair injury and damage due to disasters."

4.2.5 Changes and Challenges in Capabilities

As the Missouri State Hazard Mitigation Plan has evolved, the State's capabilities for mitigation have grown. An evaluation of the pre- and post-disaster capabilities took place on a program level during the 2013 update. This program-level evaluation was based on increases in community participation in programs such as the National Flood Insurance Program (NFIP) and StormReady, local community planning efforts, successful acquisition of new pre- and post-disaster mitigation project funds, and peer evaluation of the State's emergency management program. A greater number of communities are participating in the NFIP, partnerships among federal and state agencies and local governments continue to grow, and new strategic planning efforts have been undertaken. These changes in programs, outreach and partnerships, plans, and policies and regulations are summarized below. The end of this chapter discusses the challenges and opportunities in continuing to enhance state capabilities.

SEMA's overall program has been strengthened by legislation (Missouri House Bill 579) that transferred SEMA from the Office of the Adjutant General to the Department of Public Safety. This allows for the deployment of any healthcare provider who is licensed, registered, or certified in Missouri or any other state and volunteers during an emergency declared by the governor. Prior to the bill's passage, only workers licensed, registered, or certified in Missouri could be deployed. The bill granted volunteers

immunity from civil damages for their services unless the damages are due to willful and wanton acts or omissions in rendering care. The Department of Health and Senior Services is allowed to recruit, train, and accept the services of citizen volunteers to dispense medication in a public health emergency.

Another indication that SEMA's overall emergency management program was obtained through a standard of excellence accreditation from the Emergency Management Accreditation Program (EMAP). Full accreditation was received from the National Emergency Management Association in 2007. SEMA underwent the EMAP voluntary assessment which is a peer-review evaluation and accreditation process for state and local government programs responsible for coordinating prevention, mitigation, preparedness, response, and recovery activities for natural and manmade disasters. Accreditation is based on compliance with collaboratively developed national standards. By complying with the EMAP mitigation standards, Missouri has demonstrated the importance it places on emergency management, including mitigation, and as a result is better prepared to protect its residents and property from hazards.

Participation in the NFIP has increased between the publication of the 2010 plan and May 2013 (see Table 4.2.5a as 38 additional communities have joined the program. Mitigation planning and the Pre-Disaster Mitigation grant program have had a positive impact on participation of the NFIP. The program is expected to continue to grow in the future. The number of total suspended communities has decreased by three.

Table 4.2.5a Changes in NFIP Participation, 2010-2013

NFIP Participation	2010	2013
Total in Regular Program	604	650
Total in Emergency Program	10	2
Total in NFIP	614	652
Mapped Hazard Area, Not in Program	118	161
Total Suspended	10	8

Source: NFIP Community Status Book January 2010

In Missouri, FEMA's Risk Map program is ongoing and as of January 2013, 73 counties have effective, county-wide digital Flood Insurance Rate Maps (DFIRMs). A map of the status of the DFIRM counties is located in the levee discussion in Section 3.3.7 of Chapter 3.

SEMA organizes annual grant mentoring workshops, one for each grant cycle, to help local governments develop Hazard Mitigation Assistance subgrant applications, benefit-cost analyses, and eGrant (Electronic Grant Application) applications. This includes the non-disaster (annually funded) grant programs of PDM, FMA, RFC, SRL, and the post-disaster grant program – HMGP. The workshops assist local governments and Regional Planning Commissions/Councils of Government (RPC) planners with their applications. In 2009 alone, SEMA trained approximately 50-60 people at their workshops.

Since 2004, the number of approved local mitigation plans has increased significantly. As of April 2013, 85 of 114 Missouri counties have approved hazard mitigation plans that meet the requirements of both

the Disaster Mitigation Act of 2000 and the Flood Mitigation Assistance Program. Another 28 counties (including the St Louis City) are in the process of updating their plan and/or in process of their first plan.

In regard to these local planning efforts, the RPCs proved themselves to be an extremely valuable asset in developing and approving plans and increasing awareness of mitigation and integrating it with other planning efforts. For more information on completed local hazard mitigation plans, see Section 5.1.2 Local Plan Development Status.

Since 2009, Missouri has updated the Emergency Operations Plan, Children's Division and , the State Emergency Operations Plan.

Since the 2007, Missouri has made significant progress in preparing its communities for severe weather. With a total of 53 StormReady designations, Missouri has increased the number of communities and commercial sites participating in the program. In early 2007, there were only 16 counties, 25 communities, 1 commercial site (there are only 5 nationwide), and 1 university participating in StormReady. As of May 28, 3013, Missouri had 20 counties, 41 communities, two commercial sites, and four universities that are recognized as StormReady.

The Missouri Dam and Reservoir Safety Program is making progress with inundation mapping of the high hazard dams in the State and anticipating that will be completed by 2014. Currently, the State regulates about 682 dams. Of those, 203 are Class 1, 255 are Class 2, and 224 are Class 3 dams.

4.2.6 Implementation Opportunities and Challenges

This section summarizes the opportunities for improving state capabilities and opportunities and challenges related to the implementation of mitigation laws, regulations, policies, and programs. It also highlights the pre- and post-disaster tools, policies, and programs that have proven to be successful in achieving Missouri's mitigation objectives.

As mentioned previously, the Local Mitigation Planning Project has been quite successful. Because of SEMA's partnership with the RPC's, 94 percent of Missouri's population is covered by an integrated hazard mitigation plan. This relationship is making mitigation champions out of the RPCs. As they assist other communities, the RPC's are able to use multi-objective management and consider where and how mitigation can be incorporated into the planning effort. SEMA will continue to use the RPCs and provide them with support and education to further mitigation in the State.

Mitigation planning, especially at the local level, has greatly increased the awareness and importance of mitigation throughout the State. This has subsequently increased interest in mitigation grant programs and the number of local applications for project funding. This is both a success and a challenge due to increased workloads in processing grant applications.

SEMA's mitigation program has historically maintained a staffing level to manage approximately $25 million in grants. However, due to the program's success in obtaining funding through the competitive Pre-Disaster Mitigation program and multiple disasters, SEMA is managing over $100 million. This presents challenges for personnel time. SEMA has met this challenge by contracting with the Regional Planning Commissions for planning, plan reviews, and completing closeout reports. Then in 2007, the governor allowed for the addition of a full-time contracted employee specifically for the Mitigation

Section. This employee works directly with local planners to assist and review the new and updated local hazard mitigation plans.

The Community Buyout Program in both a pre- and post-disaster environment remains an important tool for moving people and property out of flood hazard areas. One challenge of the program is the lack of flexibility in developing alternate public uses of acquired properties, such as for bridges or public transportation right-of-ways. Another is ensuring that communities know about and comply with the deed restrictions. While this program and other flood-related mitigation actions are still the State's top priority, tornado safe rooms are requested more frequently in the wake of the tornado activity in the past few years.

Missouri Water Resources Law addresses water inventory and monitoring, source water assessment and protection, dam safety, and the Water Plan; however, no state water appropriations law exists. This presents a challenge as demands on water resources continue to increase.

Missouri Revised Statute 245.015 allows for the creation of levee districts to protect land subject to overflow, overwash, and bank erosion. Because Missouri is a home-rule state, it has limited authority over these levee districts. FEMA established policies for the evaluation of the certification or decertification of existing or proposed levees as DFIRMS are being developed. SEMA supports FEMA in categorizing these levees as accredited levees, provisionally accredited levees, and de-accredited levees. Counties that are designated as third or fourth class based up on their assessed valuation cannot implement certain zoning and land use regulations. Among these regulations are floodplain ordinances necessary to comply with the NFIP. *RSMo 49.600*, listed in Table 4.2.2a, mandates that in certain second-, third-, or fourth-class counties no floodplain ordinance is effective unless authorized by voters.

More information on successful mitigation programs and projects in Missouri can be found in Section 7.5 Effective Use of Available Mitigation Funding.

4.3 Local Capability Assessment

Requirement §201.4(c)(3)(ii):	[The State mitigation strategy shall include] a general description and analysis of the effectiveness of local mitigation policies, programs, and capabilities.

The local capability assessment provides a general description of local mitigation capabilities in Missouri, including examples of successful policies and programs, followed by an analysis of the effectiveness of these capabilities. The assessment concludes with a discussion of opportunities and obstacles to implementing and strengthening local capabilities.

4.3.1 Methodology

SEMA analyzed 106* FEMA-approved local hazard mitigation plans to inventory capabilities and assess their effectiveness. SEMA's initial 2002 local mitigation planning guidance recommended and provided

information for the development of a capability assessment, which goes beyond the minimum local planning requirements of the Disaster Mitigation Act and enabled this inventory and analysis. A table created to capture local capabilities was provided in SEMA's guidance document and a summary of those local capabilities was created for this plan. Information related to the following categories of capabilities was captured:

- Personnel
- Technical
- Fiscal
- Land Use Planning and Building Codes
- Coordination and Partnerships
- Education and Outreach
- Other Capabilities

Note: 106* includes 104 local plans that have been FEMA approved, updated, and/or expired. It also includes two county plans of Laclede and Pulaski that were included in the 2013 plan update, but have never been approved by FEMA.

4.3.2 Local Policies, Programs, and Capabilities

A general description of local capabilities, both existing and emerging, from the analysis of local plans is summarized below for each of the categories of capabilities identified in the methodology.

Personnel

All 114 counties in Missouri have an Emergency Manager position and currently none are vacant. There are also another 460 cities, five towns and 98 villages with Emergency Manager positions reported to the State.

Other personnel capabilities vary greatly across the State. Larger, wealthier counties have full-time planners and engineers; smaller, less affluent counties do have not full-time planners or engineers. Other personnel capabilities include administrators for grant funding programs. Some counties described the need for a full-time information technology manager to enhance their technical capabilities and to better utilize geographic information systems (GIS) data.

Technical

The primary technical capability evaluated by the local governments was GIS analysis, which is valuable for mapping hazard areas and comparing hazards areas with vulnerable areas and assets in the community. Many plans identified GIS capabilities. Regional Planning Commissions (RPCs), who were contracted by the State to develop local hazard mitigation plans, provided some GIS support to smaller rural counties to help them complete their plans. Other technical capabilities discussed in local plans include joint communications centers and advanced warning systems.

Fiscal

The analysis of local plans indicates that most local governments do not have specific local funding sources for mitigation and rely on federal programs, such as the HMGP, PDM, FMA, SRL and RFCPrograms, to fund pre- and post-disaster mitigation projects. Through tax-funded investments in infrastructure improvements, local governments are able to fund some projects that have mitigation effects, such as replacing culverts or structural improvements to critical facilities. These funds come predominantly from property and sales tax revenues and are generally allocated directly to schools,

public works, and other essential government functions. Mitigation can be accomplished with this revenue stream through projects that meet multiple objectives. For instance, money allocated for school repairs can be used to replace a school's roof with better wind resistant materials.

Some counties and municipalities have dedicated transportation or capital improvements sales or use taxes that can be obligated to fund mitigation projects. Many counties have fully allocated their current tax collections and do not have significant additional amounts for mitigation projects. A sales tax or bond issue to help fund mitigation actions would require a vote of the citizenry and could be difficult to pass. In Callaway County, the City of Holts Summit approved a one-eighth cent sales tax in 2001 for emergency preparedness. This tax funded the purchase and installation of five emergency warning sirens, a back-up generator for city hall and the police department, and provided the 25 percent local share for a PDM grant that was used to build a community tornado safe room. The safe room was completed in July 2009.

Coordination and Partnerships

Some local governments have intergovernmental or interagency committees that meet regularly. These organizations often take the form of an emergency management committee that meets monthly. Other communities use their local emergency planning committee (LEPC) to coordinate emergency management and mitigation issues. LEPCs are required by the Emergency Planning and Community Right-to-Know Act of 1986. The purpose of this act is to encourage and support emergency planning efforts at the State and local levels and provide the public and local governments with information concerning potential chemical hazards. Membership of the LEPCs includes representatives of public and private organizations as well as representatives from every facility in the jurisdiction subject to the emergency planning requirements of the act. At least one Missouri county has combined their LEPC and emergency management committee into one entity; other counties have both types of committees operating simultaneously. In several counties, the hazard mitigation planning committee continues to meet regularly to coordinate and monitor mitigation activities and progress.

Another indicator of the long-term success of local mitigation plans is their integration with other local plans and programs. Many local governments describe the coordination of their mitigation plan with their emergency operations plan. St. Charles County integrated its mitigation plan with the county master plan which resulted in a framework for supporting growth while promoting best management practices and policies relating to stormwater and floodplain management.

Education and Outreach

The State reviewed local plans for reference to mitigation-related education and awareness programs. Some counties promote seasonal hazard awareness campaigns and many have trained their employees in hazards and emergencies. Some counties perform outreach activities for their floodplain management program or work with the media to raise awareness of certain hazards. Some of the counties indicated that they provide moderate to substantial curriculum on hazards and emergency management in elementary and secondary schools.

Other Capabilities

This section summarizes other local capabilities that do not fit into the previously listed categories. Some local mitigation plans describe right-of-way tree-trimming programs as a mitigation capability. Through these programs, local governments trim and maintain trees along utility right-of-ways to prevent damage to utilities during severe weather events. Gentry and Atchison Counties have water

conservation programs in several of their cities that they consider to be capabilities for drought mitigation, and Christian County has a dedicated drought plan.

Several communities participated in a buyout program to mitigate flood losses by acquiring flood-prone properties. Four Missouri communities, the City of Independence, City of Kansas City, Platte County, and St. Charles County, currently participate in the NFIP's Community Rating System (CRS), a voluntary incentive program that recognizes and encourages community floodplain management activities that exceed the minimum NFIP requirements.

The Columbia-Boone County Storm Water Task Force was developed to advise the City of Columbia and Boone County on regulations, practices, and policies to improve stormwater management. This Task Force looked at overall stormwater quality, reducing damage to streams, minimizing damage to public and private property through increased stormwater flows, and protecting the quality of life for residents. The group considered both structural and nonstructural practices in formulating its recommendations and meets monthly to discuss changes and updates to stormwater regulations. While the task force has an environmental focus, it also considers mitigation, thus it addresses multiple community objectives. Boone County passed their stream buffer ordinance in May of 2009 and in January 2010 they had a final draft of their stormwater ordinance available for adoption.

4.3.3 Effectiveness of Local Mitigation Capabilities

The SRMT identified and analyzed the effectiveness of the most common local mitigation policies, programs. An exercise of the SRMT ranked local communities' mitigation effectiveness as High Effectiveness, Moderate Effectiveness, and Low Effectiveness through a voting system. They were instructed to use their expertise and general working knowledge of local policies and programs to base their decision. Table 4.3.3a indicates the results of how the SRMT ranked the effectiveness of local communities' mitigation policies and programs. Emergency operations plans were rated as the most effective local mitigation tool. Building codes and zoning codes were ranked as the next highest by the SRMT.

Table 4.3.3a Effectiveness of Local Capabilities as Ranked by the SRMT

Local Mitigation Policy or Program	Percentage of Effectiveness Votes		
	High	Moderate	Low
Building Codes	65%	30%	0%
Comprehensive/ Master Plans	33%	67%	0%
Earthquake Design Regulations	24%	38%	38%
Emergency Operation Plans	75%	25%	0%
Floodplain Regulations	33%	67%	0%
Stormwater Regulations	25%	50%	25%
Subdivision Regulations	8%	25%	67%
Zoning Codes	50%	33%	17%

Local plans ranked floodplain regulations as the most effective mitigation capability. Ninety-Seven percent of those plans ranked floodplain regulations as highly effective. Participation in the NFIP was ranked as being highly effective in ninety-one percent of the plans. Very few local plans ranked any of the capabilities evaluated as having low effectiveness for mitigation.

This disparity in rankings by the SRMT and the local plans demonstrated the continued need for mitigation training and education. It shows that State agency representatives are not as familiar with local mitigation-related regulations as local planners are. But continued involvement of State agency representatives with all phases of emergency management will continue to increase their understanding of local mitigation policies and programs.

4.3.4 Opportunities for Improving Local Capabilities

This section discusses opportunities for strengthening local capabilities that have been identified based on the analysis of local programs, policies, and capabilities. The State will use these opportunities and obstacles to strengthen local capabilities identified in this assessment and to update their mitigation strategy and enhance local planning coordination.

Local Funding

The analysis of local plans indicates that most local governments use federal funds for mitigation. Local governments have met federal mitigation program match requirements through in-kind services, their general fund, and state general revenue; however, state general revenue is no longer available for this purpose due to budget constraints.

One approach communities are using to overcome this funding obstacle is by improving the integration of mitigation plans with other local plans and programs, such as capital improvement plans. This helps to achieve mitigation through other community objectives. Another approach is taking cost-effective mitigation measures into consideration when developing capital improvement projects.

A dedicated tax revenue source for mitigation is difficult to implement because tax increases are generally unpopular with the public. The public is also often unaware of the real costs of disasters and benefits of mitigation. Continued public education and awareness of hazard vulnerabilities and mitigation options may help attract funding for mitigation through tax dollars and private sources. The best time to implement such a campaign is in the immediate aftermath of a disaster. A tax designated to targeted, tangible benefits, such as funding an emergency manager position and/or an advance warning system, may be more acceptable to the public. The State has had local success with federal funding programs by efficiently managing the programs and providing assistance to local governments with applications, ideas for meeting match requirements, and continued eligibility.

Public Education and Outreach

Public education and awareness about natural hazards risks and mitigation is an important component in most local plans. Education and outreach has led to greater household preparedness, public participation in and support for mitigation policies and programs, as well as political support to address and fund mitigation needs. Seasonal hazard awareness campaigns are one outreach tool that many local governments use to enhance public awareness.

Technical Support

GIS and other technical assistance from the State remains an important resource for smaller communities with limited capabilities. Regional Planning Commissions (RPCs) provide additional GIS and technical support to communities who need such assistance. The State has helped and will continue to help local governments with limited capabilities overcome this obstacle by collecting information on what types of technical assistance are needed. To further assist local governments with their planning, SEMA shares the results of Hazus reports, projects, and associated GIS data created for the purposes of the 2013 plan update. This data is available for every county in Missouri (link).

Regional Planning

The use of RPCs in Missouri to facilitate local mitigation planning has been quite effective (see Section 5.1 Coordination of Local Mitigation Planning for more information). As mentioned previously, the RPCs are important resources to strengthen local technical capabilities. Regional planning efforts also enable the coordination of land use issues to prevent one jurisdiction from engaging in activities that adversely impact another. As local governments begin to update their local hazard mitigation plans, partnerships with the RPCs will allow the State to exchange information and reinforce capabilities with local governments.

Local Plan Update Guidance

In 2002, SEMA produced a guidance document for the initial development of local hazard mitigation plans. FEMA has produced a series of how-to guide for local plan updates. This allows the State to communicate information and encourages the strengthening and implementation of local capabilities identified in this 2013 state plan. This may include encouraging existing intergovernmental local emergency management committees to take a larger role in mitigation by prioritizing activities and in monitoring progress of the plan and encouraging better integration with community comprehensive plans, capital improvement plans, and other long-term community goals. The updated guidance can also align the monitoring and evaluation goals of the state plan with the local update process to create more effective feedback. In 2008, FEMA produced a Hazard Mitigation Planning Guidance that is also available to the local communities. New guidance and the FEMA review tool was provided in October 2011, as well as the Handbook in March 2013.

Land Use Planning and Regulations

Local governments are using land use planning to identify areas at risk to natural hazards and to keep those areas from developing inappropriately. Local governments are also starting to look at the negative impacts of existing and future planned subdivision developments and what measures can be implemented to reduce or eliminate them. Combinations of stormwater retention/detention projects along with locally funded buyouts are making a significant difference in this area.

Floodplain Management

Local governments rank floodplain management and NFIP as highly effective mitigation capabilities. Floodplain management and the NFIP remain key opportunities to strengthen local capabilities. The State has facilitated this by continuing to enhance its program that encourages and supports new participation in the NFIP and in the CRS Program. Additionally the State is helping existing participants in the NFIP and CRS promote and enforce their floodplain management programs.

4.4 Mitigation Actions

Requirement §201.4(c)(3)(iii):	[State plans shall include an] identification, evaluation, and prioritization of cost-effective, environmentally sound, and technically feasible mitigation actions and activities the State is considering and an explanation of how each activity contributes to the overall mitigation strategy. This section should be linked to local plans, where specific local actions and projects are identified.
Update §201.4(d):	Plan must be reviewed and revised to reflect changes in development, progress in statewide mitigation efforts and changes in priorities.

This section introduces the mitigation action categories considered by the State to meet the goals and objectives of this plan. Each category is listed, followed by background on how they were identified and prioritized. This section also describes how the action categories were reviewed during the 2013 update to reflect changes in risk, progress in statewide mitigation efforts, and changes in priorities. It further describes the progress of implementation for those mitigation actions and concludes with an analysis of local mitigation actions summarized from the available local mitigation plans including the challenges associated with implementing them.

4.4.1 Categories of Mitigation Actions in Missouri

There are 11 action categories that SEMA and the SRMT have identified to fulfill this plan’s goals and objectives. These action categories must comply with all federal and state requirements for mitigation funding, which means they must be cost-effective, environmentally sound, and technically feasible. The action categories listed below are the primary ones the State supports for addressing the hazards analyzed in this plan (which is not an all-inclusive list) and are a continuation from the 2010 plan. This is followed by a brief description of the types of projects associated with each action category.

- M1—State and Local Hazard Mitigation Plans (required to qualify for mitigation funding)
- M2—National Flood Insurance Program Floodplain Management and Community Rating System
- M3—Voluntary Property Acquisitions (Flood Buyout)
- M4—Voluntary Elevation, Relocation, Floodproofing
- M5—Tornado Safe Rooms
- M6—Earthquake/High Wind Structural Mitigation Projects
- M7—Earthquake/High Wind Nonstructural Mitigation Projects
- M8—Structural/Infrastructure Mitigation Projects (including Public Assistance projects)
- M9—Buried Electric Service Lines
- M10—State 5% Initiative Projects
- M11—Technical Assistance

Mitigation Action Categories With Project Descriptions

M1—State and Local Hazard Mitigation Plans
This includes activities related to mitigation planning at the State and local level and includes completing remaining local mitigation plans and updating existing plans, developing or revising guidance (as appropriate), and providing training.

M2—National Flood Insurance Program Floodplain Management and Community Rating System
This category includes promotion of participation in the National Flood Insurance Program (NFIP) and the wise use of floodplains. Activities can include floodplain management workshops, flood insurance promotion, community assistance visits, floodplain map modernization activities, streambank stabilization, and minor flood control. Communities willing to exceed the minimum NFIP regulations, particularly those with large policy bases, are encouraged to join the Community Rating System. SEMA has established an awareness website, http://floodplain.sema.dps.mo.gov/MONFIP/Default2.aspx, for all interested parties to gather NFIP information in Missouri.

M3—Voluntary Property Acquisitions
These projects entail partnering with local entities to buy out properties at risk to flooding. This is SEMA's most important mitigation action, and usually most cost-effective, because the people and property are totally and permanently removed from the path of flooding and danger. SEMA supports acquisitions of residential property and not commercial property at this time. SEMA's top priorities for acquisition are repetitive flood loss properties and severe repetitive loss properties.

M4—Voluntary Elevation, Relocation, Floodproofing
These projects, in partnership with local entities and property owners, are additional ways to reduce the impacts of flooding. Elevation of flood-prone properties may be used if it is proven to be cost-effective and desirable over the long term (e.g., when the cost of the land is so high that a buyout is impractical). Relocation may be used if it is more practical/cost-effective or when the threat is so severe or has the potential to be repetitive that it is more advantageous to relocate a structure or structures, up to and including entire communities, entirely out of harm's way. Floodproofing may be more feasible in areas of limited danger, particularly for commercial properties (the NFIP does not recognize dry floodproofing for residential structures).

M5—Safe Rooms
These are projects that protect people from tornadoes and high winds and must also comply with FEMA Publications 320 and 361, which prescribe safe room and shelter construction standards. Projects can range from rooms in non-profit organization (Habitat for Humanity) sponsored homes that protect individual families to large-scale community safe rooms in public buildings and schools. These projects can often meet multiple community objectives, such as a combination school gymnasium/safe room. Safe rooms can also be standalone buildings or internal buildings that are intended to provide protection during a short-term high-wind event, like a tornado. Safe rooms have proven to be successful during these events.

M6—Earthquake/High Wind Structural Mitigation Projects
These projects reinforce structural components of a building to resist seismic and/or high wind loads. There is an emphasis on critical facilities or facilities that would impact life safety if they were to fail due to the hazard.

M7—Earthquake/High Wind Nonstructural Mitigation Projects

These projects reduce life safety impacts and in some cases can limit damage to nonstructural building elements, such as building utility and lighting systems. Examples include window film and strapping and bracing appliances and fixtures, such as water heaters, shelves, etc.

M8—Structural/Infrastructure Mitigation Projects (including Public Assistance projects)

These projects develop structures to redirect or modify the impact of a hazard, such as a floodwall or stormwater collection system. Public Assistance refers to FEMA's post-disaster program that funds repair or replacement of damaged infrastructure and can sometimes be used for mitigation, depending on the type of damage. An example would be replacing a washed out culvert with one designed to convey higher flood flows or replacing a cylindrical corrugated pipe with a box culvert. Bridges and low water crossings are other examples that have been funded.

M9—Buried Electric Service Lines

These projects mitigate utility outages and repair costs from severe weather events such as ice storms, high winds, and tornadoes.

M10—State 5% Initiative Projects

These projects are those that are worthwhile but difficult to prove cost-effective and refer to the five percent of Hazard Mitigation Grant Program funds that, following a disaster, can be set aside for projects such as development of community outreach programs and materials, increasing weather radio coverage, hazard studies, warning sirens, generators, etc.

M11—Technical Assistance

This category applies to various efforts from multiple state agencies to provide technical assistance, including training, in the identification and mitigation of hazards. The technical assistance can be for local governments or to update state policies and legislation. SEMA also makes a considerable effort to educate the public, local officials, government officials, schools, private associations, and businesses about the value and importance of mitigation programs. SEMA offers mitigation workshops, participates in public forums, provides one-on-one counseling, presents at conferences, provides written materials, develops guidebooks and manuals, publishes success stories, sends out press releases, offers information on the Internet, and provides training materials to local emergency managers, earthquake program partners, floodplain managers, and businesses.

Table 4.4.1a shows how these 11 action categories meet the objectives and goals identified in Section 4.1 Hazard Mitigation Goals and Objectives and thus contribute to the overall mitigation strategy. Some of these action categories have already proven successful, as demonstrated in Section 7.5 Effective Use of Available Mitigation Funding.

Table 4.4.1a Mitigation Action Categories and Goals Crosswalk

Objectives	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11
Goal 1: Improve the Protection of Human Life, Health, and Safety											
Objective 1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Objectives	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11
Objective 3	✓	✓			✓	✓	✓			✓	✓
Objective 4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 5	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Goal 2: Improve the Protection of Continuity of Government and Essential Services Safety											
Objective 1	✓	✓			✓	✓	✓	✓	✓	✓	✓
Objective 2	✓	✓			✓	✓	✓	✓	✓	✓	✓
Objective 3	✓	✓			✓	✓	✓	✓	✓	✓	✓
Objective 4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 5	✓	✓			✓	✓	✓	✓	✓	✓	✓
Goal 3: Improve the Protection of Public and Private Property											
Objective 1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 3	✓	✓			✓	✓	✓			✓	✓
Objective 4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 5	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Goal 4: Improve the Protection of Community Tranquility											
Objective 1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 3	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 5	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

4.4.2 Process for Identifying, Evaluating, Prioritizing, and Updating Mitigation Actions

Projects in this plan were identified over years of mitigation planning in Missouri by the SRMT and its predecessors (e.g., Spell Out SHMPT and the Hazard Mitigation Project Coordinating Group). The nature of recent disasters has often dictated the project types and hazards addressed. In the 1990s, the widespread flooding emphasized the importance, and benefits of, removing properties from the floodplain. Missouri's drought and tornado events in more recent years have shifted the local interest and focus from flood projects to tornado safe rooms. Identification of specific local mitigation actions typically comes from communities impacted by a disaster, or in more recent years, from proactive communities with local mitigation plans applying for pre-disaster grant funding.

All of the mitigation actions have proven to be effective based on past experience with some more effective than others. Effectiveness is measured in general terms based on how well the project meets multiple objectives:

- **High**—mitigates impacts to life safety and property
- **Moderate**—mitigates impacts to life safety only or property only

For example, flood buyout projects not only remove property from the floodplain, but they remove the risk to lives in the floodplain as well and eliminate the need to put first responders' lives in jeopardy during flood events. A tornado safe room may reduce deaths and injuries, but they may not necessarily reduce property damage. Table 4.4.4a includes the general effectiveness of each action. Effectiveness of specific projects is measured using FEMA's benefit-cost software modules, which is described in more detail in Section 7.2.4 Pre-Project Determination of Cost-Effectiveness of Mitigation Measures. More communities are joining the NFIP and a majority of the counties have a FEMA-approved hazard mitigation plan.

SEMA uses the STAPLEE (social, technical, administrative, political, legal, economic, and environmental) criteria in evaluating mitigation projects and the following criteria to assess the mitigation actions depending upon the current situations and threats:

- Flood mitigation projects (repetitive loss properties high priority)
- Tornadoes and high wind mitigation projects
- Earthquake mitigation projects
- Other, not direct life safety

STAPLEE is used as a screening tool to determine if the project makes sense and is worthy of consideration and implementation. During the 2013 update, SEMA measured each of the 17 mitigation actions against the modified STAPLEE criteria and completed the STAPLEE worksheet (see Figure 4.4.2.1).

The overall STAPLEE score is presented in Table 4.4.3a. All the mitigation actions were automatically ranked using the above criteria and the mitigation action M category under which the project falls.

Figure 4.4.2.1 - Modified STAPLEE Worksheet

2013 MO SHMP STAPLEE Exercise

Action 1

Track local community hazard mitigation plans to ensure completion of new plans and updates to existing plans as their 5-year cycle expires. (Action Category M1)

*** 5. STAPLEE Criteria**

Please rate the following criteria as they related to the action identified above. Use the following evaluation scoring criteria when selecting your rating:
3 = Definitely YES
2 = Maybe YES
1 = Probably NO
0 = Definitely NO
N/A = I do not feel qualified to rate this question

	3	2	1	0	N/A
Is it Socially acceptable?					
It is Technically feasible and potentially successful?					
Does the responsible state agency/department have the administrative capacity to execute this action?					
Is it Politically acceptable?					
Is there Legal authority to implement?					
Is it Economically beneficial?					
Will the project have either a neutral or positive impact on the natural Environment? (score a 3 if positive impact, 2 if neutral impact)					
Will historic structures be saved or protected?					
Could it be implemented quickly?					

*** 6. Mitigation Effectiveness Criteria**

For the 1st question below: Assign 5-10 points based on the likelihood that lives would be saved (10 being the highest likelihood)

For the 2nd question below: Assing 5-10 points based on the relative reduction of disaster damages (10 being the most reduction)

	5	6	7	8	9	10
Will the implemented action result in lives saved?						
Will the implemented action result in a reduction of disaster damage?						

7. Please add any additional comments pertaining to this Action below:

Prev Next

During the 2013 plan update, SEMA assessed existing actions and developed new actions for consideration based on:

- Review of the updated state risk assessment and information from local risk assessments;
- Review of goals and objectives;
- Review and assessment of existing state actions, including priorities;
- Review of state and local capabilities; and
- Review of a summary of commonly used actions identified in local plans.

Ongoing, revised, and new actions and how they fit with the M categories are summarized in Section 4.4.5 Review and Progress of Mitigation Actions.

4.4.3 2013 Updated Mitigation Actions

Table 4.4.3a details actions that the State is considering to further the implementation of mitigation actions in Missouri. The actions recommended are a result of the 2013 plan review and update and can be accomplished with state effort and/or resources. The table also includes the Action Category M1-M11, the Action Title, the lead agency, and supporting agencies. The overall STAPLEE score is listed with the status of the action for this 2013 plan update and potential funding sources for the actions turning into projects. There are no new sources of funding identified in the table below.

Table 4.4.3b details the actions and how they relate to the different hazards.

Table 4.4.3a Summary of Mitigation Actions for 2013 Updated Plan

Action #	Action Category	Action Title	Lead Agency	Support Agencies	STAPLEE Score	Status	Status Report	Funding Source
1.	M1	Track local community hazard mitigation plans to ensure completion of new plans and updates to existing plans as their 5-year cycle expires.	SEMA	COG's RPC's	36	Revised 2013	The revision is to continue updating plans as they expire.	HMGP, PDM, SEMA Operating Budget
2.	M1	Provide technical assistance and available funding to RPCs to develop new and updated local community plans, using the latest FEMA guidance materials with emphasis on standardized risk assessment methods.	SEMA	COG's RPC's	36	Revised 2013	The revision is to include new and updated local community plans.	HMGP, PDM, SEMA Operating Budget
3.	M1	Use RPCs and SEMA staff to encourage implementation of actions in local plans	SEMA	COG's RPC's	36	Ongoing for 2013	This will continue with the 2013 update.	SEMA Operating Budget
4.	M1	Develop vulnerability assessments for additional hazards besides flood, tornado, and earthquake, such as severe winter storms, for the 2010 update of the state hazard mitigation plan.	SEMA	Other agencies with pertinent data.	38	Ongoing for 2013	With the 2013 Update, vulnerability assessments were completed for all 21 hazards. New data will continue to enhance the vulnerability section as future updates are completed.	HMGP, PDM, SEMA Operating Budget
5.	M2	Continue to encourage new participation in the National Flood Insurance Program and the Community Rating System and encourage existing participants to promote and enforce their floodplain management programs	SEMA	FEMA	38	Ongoing for 2013	NFIP and CRS will continue to be encouraged and promoted in Missouri.	FMA, CAP, HMGP, PDM, SEMA Operating Budget
6.	M3	Enhance flood buyout and mitigation project tracking system with a goal to enable as a GIS database	SEMA	FEMA	37	Ongoing for 2010	A cost avoidance tracking system has been updated with this 2013 Enhanced Plan Update.	FMA, HMGP, PDM, SEMA Operating Budget

Action #	Action Category	Action Title	Lead Agency	Support Agencies	STAPLEE Score	Status	Status Report	Funding Source
7.	M4	Continue to pursue mitigation of flood-prone properties, specifically identified severe repetitive loss properties and repetitive loss properties.	SEMA	CDBG	37	Ongoing for 2013	Severe Repetitive Loss Properties & Repetitive Loss Properties continue to be a Top Priority for Property Buyouts in Missouri.	SRL, FMA, RFC, HMGP, CDBG, PDM,
8.	M5	Support the construction of tornado safe rooms in local communities' public buildings, public schools, and eligible private non-profit facilities to FEMA standards.	SEMA	COG's RPC's DESE, DHE, non-profit organizations	35	Ongoing for 2013	This is a priority, following flood buyout properties, for grant funds in Missouri & continues to be updated in the 2013 Plan Update.	HMGP, CDBG, PDM
9.	M6	Support the Missouri Statute "Earthquakes - Seismic Building and Construction Ordinances," to require public buildings in the State of Missouri to be designed in accordance with building codes based upon the latest version of the National Earthquake Hazards Reduction Program (NEHRP) provisions for the design of new buildings.	SEMA	DNR COG's RPC's	33	Ongoing for 2010	This is a priority in Missouri & and continues to be supported through SEMA efforts.	SEMA Operating Budget
10.	M7	Public Education of Earthquake/High Wind nonstructural mitigation measures	SEMA	DNR COG's RPC's	34	Ongoing for 2010	These are recognized as significant hazards in Missouri & is supported through SEMA and continues to be updated in the 2013 Plan Update.	SEMA Operating Budget
11.	M8	Support the use of PA mitigation funds in Missouri	SEMA	FEMA Local Communities	35	Ongoing for 2010	PA mitigation funds will continue to be used in Missouri and has ben updated in the 2013 Plan Update.	PA mitigation funds
12.	M9	Continue to pursue mitigation of municple and public electric provider's services.	SEMA	Municipal and public electric providers	33	Ongoing for 2010	This is recognized as a good use for grant funds in Missouri and ongoing projects & thus updated in 2013 Plan Update.	HMGP, CDBG, PDM,
13.	M10	Support projects that are consistent with the State goals & objectives, but difficult to quantify the benefits using the standard BCA (i.e. warning sirens, permanently installed generators, etc)	SEMA	COG's RPC's	35	Ongoing for 2010	This is a consideration for HMGP 5 % set aside funds in Missouri & thus been updated in 2013 Plan Update.	HMGP

Action #	Action Category	Action Title	Lead Agency	Support Agencies	STAPLEE Score	Status	Status Report	Funding Source
14.	M11	Provide HAZUS-MH results to RPCs and local governments for mitigation planning purposes and to promote consistency in the updates to local plan risk assessments.	SEMA	COG's RPC's	35	Ongoing for 2013	Hyperlinks in this 2013 Plan Update will direct RPC's to HAZUS county flood maps.	SEMA Operating Budget
15.	M11	In cooperation with Missouri agencies that own, operate, and/or lease state facilities, continue to improve work to geolocate their facilities as data becomes available to further refine risk assessments using GIS.	SEMA	MDC, MHE, MoDOT, OA	33	Revised 2013	The revision includes all state agencies that own, operate, and/or lease state facilities. This list will continue to be incorporated when this plan is updated every 3 years or as required.	Missouri state funds
16.	M11	Support and provide technical assistance for FEMA Risk MAP Products to promote mitigation actions.	SEMA	FEMA	37	Ongoing for 2013	This will continue in the 2013 update.	PDM, SEMA Operating Budget
17.	M11	Encourage the creation of Levee Safety Program	SEMA	DNR, COE	34	Revised for 2013	The National Committee on Levee Safety supports the creation of state-level levee safety programs.	Missouri state funds, COE funds
18.	M2	Support and provide technical assistance for FEMA Risk MAP Products to promote mitigation actions.	SEMA	FEMA		Revised for 2013	NFIP and identification of flood hazard areas will continue to be encouraged and promoted in Missouri.	FMA, CAP, HMGP, PDM, SEMA Operating Budget

Note:

Supporting Agencies: COE (U.S. Corps of Engineers), COG (Council of Governments), DNR (Missouri Department of Natural Resources), FEMA (Federal Emergency Management Agency), MDC (Missouri Department of Conservation), DHE (Department of Higher Education), MoDOT (Missouri Department of Transportation), OA (Missouri's Office of Administration), RPC (Regional Planning Commissions) SEMA (State Emergency Management Agency)

Funding Sources: CDBG (Community Development Block Grant) HMGP (Hazard Mitigation Grant Program); PDM (Pre-Disaster Mitigation); FMA (Flood Mitigation Assistance); RFC (Repetitive Flood Claims); SRL (Severe Repetitive Loss)

Table 4.4.3b How Actions Relate to the Different Hazards.

Mitigation Actions	Dam Failures	Drought	Earthquakes	Fires	Heat Wave	Subsidence/Sinkholes	Levee Failure	Riverine Flooding	Severe Thunderstorms	Severe Winter Weather	Tornadoes	CBRNE	Civil Disorder	Hazardous Materials	Mass Trasportation	Nuclear Power Plants	Public Health	Special Events	Terrorism	Utilities	Cyber Disruption
1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
2	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
3	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
4	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
5	X						X	X	X												
6	X						X	X	X												
7	X						X	X	X												
8									X		X										
9			X																		
10			X			X			X		X										
11	X	X	X	X	X	X	X	X	X	X	X	X	X				X		X		
12			X						X	X	X					X			X	X	X
13	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
14			X	X				X													

Mitigation Actions	Dam Failures	Drought	Earthquakes	Fires	Heat Wave	Subsidence/Sinkholes	Levee Failure	Riverine Flooding	Severe Thunderstorms	Severe Winter Weather	Tornadoes	CBRNE	Civil Disorder	Hazardous Materials	Mass Trasportation	Nuclear Power Plants	Public Health	Special Events	Terrorism	Utilities	Cyber Disruption
15	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
16	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
17							X														
18							X	X	X												
# of Hazards Addressed	11	8	12	9	8	9	13	13	15	9	11	8	8	7	7	8	8	7	9	8	8
Probability	**L**	**M**	**H**	**M-H**	**M**	**H**	**M-H**	**H**	**H**	**L-H**	**H**	**L**	**L**	**M-H**	**M**	**M**	**H**	**L**	**L**	**H**	**MH**
Severity	**M**	**M**	**H**	**L-M**	**M**	**L**	**H**	**H**	**M**	**M**	**H**	**H**	**L-H**	**M**	**M**	**M**	**M**	**M-H**	**L-H**	**L**	**MH**

4.4.4 Mitigation Action Categories Referencing Emergency Management Accreditation Program

During the 2013 plan update, the SRMT considered the State's overall mitigation strategy in the context of the Emergency Management Accreditation (EMAP) Program's mitigation standards. EMAP is a voluntary assessment and accreditation process for state emergency management programs. Accreditation is granted only following a rigorous peer review of all aspects of a state's emergency management program. To ensure EMAP mitigation compliance, the SRMT considered the following:

- The use of applicable building construction standards;
- Hazard avoidance through appropriate land use practices;
- Relocation, retrofitting, or removal of structures at risk;
- Removal or elimination of the hazard;
- Reduction or limitation of the amount or size of the hazard;
- Segregation of the hazard from that which is to be protected;
- Modification of the basic characteristics of the hazard;
- Control the rate of release of the hazard;
- Provision of protective systems or equipment for both cyber and physical risks;
- Establishment of hazard warning and communication procedures;
- Redundancy or duplication of essential personnel, critical systems, equipment, information, operations, or materials; and,
- Educating the public about mitigation (additional measure added by SEMA—not part of EMAP)

Table 4.4.4a prioritizes the action categories, summarizes how each identified action category relates to the mitigation of specific hazards, identifies the primary agency responsible for implementation, demonstrates how the categories are linked to local mitigation plans, rates the categories' effectiveness, and ties the categories to EMAP considerations. Many of these action categories involve implementation of local mitigation projects. Local mitigation plans are proving to be a valuable resource for identifying new projects as funding becomes available or when disasters present new mitigation opportunities.

Information on specific EMAP standards can be found at http://www.emaponline.org/index.php?option=com_content&view=article&id=118&Itemid=110. All of the mitigation actions, based on past experience, can impact public safety in varying degrees of effectiveness. Effectiveness can be expressed as high, medium, or low according to the ability of the action to mitigate the hazard impacts to life, property, or both.

- **Life**— the action mitigates hazard impacts to life safety,
- **Property**— the action mitigates hazard impacts to property,
- **Both** – the action mitigate hazard impacts to both life and property.

Table 7.5a Missouri Mitigation Action Categories Strategy Overview

Action Category	Priority	Responsible Agency for Implementation	Hazards Addressed	Link to Local Plans, Actions, and Assistance	Protected by the Action	EMAP Mitigation Considerations

Action Category	Priority	Responsible Agency for Implementation	Hazards Addressed	Link to Local Plans, Actions, and Assistance	Protected by the Action	EMAP Mitigation Considerations
M1—State and Local Hazard Mitigation Plans	High	SEMA/RPCs/ local jurisdictions	All	Continued use of RPCs	Both	1,2,3,4,5,6,7,89,10,11,12
M2—NFIP Floodplain Management and Community Rating System	High	SEMA/local jurisdictions	Flood	Community assistance visits, workshops	Both	1,2,3,4,5,6, 7,8,9,12
M3—Voluntary Property Acquisitions (Flood Buyout)	High	SEMA/local jurisdictions	Flood	Projects identified in local plans	Both	2,3,6
M4—Voluntary Elevation, Relocation, Floodproofing	High	SEMA/local jurisdictions	Flood	Projects identified in local plans	Both	1,2,3,6,9
M5—Tornado Safe rooms	High	SEMA/local jurisdictions	Tornado	Projects identified in local plans	Life	1,3,6,9
M6—Earthquake/High Wind Structural Mitigation Projects	Medium	SEMA/MoDOT	Earthquake Tornado	Projects identified in local plans	Life	1,3,9
M7—Earthquake/High Wind Nonstructural Mitigation Projects	Medium	SEMA/local jurisdictions	Earthquake Tornado	Projects identified in local plans	Both	1,3,9
M8—Structural/ Infrastructure Mitigation Projects (including Public Assistance projects)	Medium	SEMA/MoDOT/ local jurisdictions	Flood	Projects identified in local plans	Both	1,2,3,5,6,7,8,9,11
M9—Buried Electric Service Lines	Low	Local jurisdictions/ certain utility providers	Multiple	Projects identified in local plans	Both	3,4,6,9
M10—State 5% Initiative Projects	Low	SEMA/local jurisdictions	Multiple	Projects identified in local plans, difficult to measure cost-effectiveness	Both	1,5,6,10,11,12

Action Category	Priority	Responsible Agency for Implementation	Hazards Addressed	Link to Local Plans, Actions, and Assistance	Protected by the Action	EMAP Mitigation Considerations
M11—Technical Assistance	Low	SEMA and other agencies	Multiple	Needs identified in local plan capability assessments	Both	1,2,3,4,5,6,7,89,10,11,12

Note:
*High denotes action mitigates impacts to life safety and property, moderate denotes action mitigates impacts to life safety only or property only

Also during the 2013 plan update, the State Mitigation Activities Matrix was updated by SRMT members. The table cross-references the EMAP standards related to hazard mitigation to all 21 of the natural and manmade hazards identified in this plan. The matrix demonstrates how mitigation is being accomplished for each hazard through multiple means, as applicable to the hazard, and integrated into the day-to-day activities of the State.

4.4.5 Review and Progress of Mitigation Actions

During the 2013 update, the status of mitigation actions implemented over the past three years were evaluated to ensure that the State is making progress with its mitigation strategy. Progress is measured based on the following variables:

- The number of projects implemented over time
- The successful disbursement of mitigation grant funds over time
- The disaster losses avoided over time (given a post-disaster event)
- Plans, partnerships, and outreach developed over time

The number of projects that incorporate mitigation while meeting other community objectives, such as a floodplain buyout that becomes a community park and natural area, is another measure of success. These are the types of successful mitigation projects that gain community buy-in and demonstrate tangible benefits. Success stories and methods of reporting them are discussed in Chapter 7 Enhanced Plan.

Another measure of progress is the achievement of mitigation on a day-to-day basis through activities of the State. Missouri measures this based on the EMAP mitigation standards as demonstrated in the previous section.

Actions that the State has been involved with between 2010 and 2013 are summarized in Table 4.4.5a. The number of actions and amount of funds dispersed through various grant programs indicate that Missouri is making progress with implementation of its mitigation strategy. The high number of tornado safe room projects (see Figure 4.4.5.1 reflects the recent tornado disasters and the momentum being built by the successful implementation of these projects across the State, especially in more rapidly developing areas where safe rooms are incorporated into the design of new structures (e.g., schools).

Figure 4.4.5.1 - Construction of Tornado Safe Rooms in Missouri

Note: Photo on left from Holts Summit safe room construction, Photo on right from West Plains safe room construction, Source: SEMA files

Low water crossings are alternatives to bridges in Missouri; however, they are dangerous when drivers attempt to use them during floods. Projects to address these low water crossing dangers entail replacing the crossings with bridges designed to accommodate flood flows. This mitigates impacts on life safety, as lives have been lost when drivers attempt to negotiate low water crossings during floods. More details on mitigation actions, including funding sources used, can be found in Section 7.5 Effective Use of Available Mitigation Funding and this link to Past Mitigation Projects.

Table 4.4.5a Summary of Mitigation Actions Implemented and Estimated Funding Amounts, 2002–2012

Project Type	Action Category	Number of Projects	Estimated Funding Amount
State and Local Hazard Mitigation Plans	M1	258	$7,885,551
Flood Buyouts	M3	67	$47,337,218
Flood Elevations	M4	3	$488,573
Tornado Safe Rooms	M5	133	$159,925,978
Tornado Safe Rooms - Multipurpose	M5	1	$686,493
Bridge Replacements	M8	1	$449,787
Low Water Crossings	M8	8	$888,246
Streambank Stabilizations	M8	2	$92,267
Basin	M8	1	$1,333,333
Culvert	M8	2	$553,625
Water Supply Interconnects	M8	1	$66,701
Buried Electric Lines	M9	10	$11,959,530
State 5% Initiative Projects	M10	12	$1753,,866

Details on the above projects, including funding sources and general timeframe are provided in Table 4.4.5b, Table 4.4.5c, Table 4.4.5d, and Table 4.4.5e. These mitigation projects solidify the State's mitigation strategy by demonstrating that the State's of goals, objectives, and actions are the basis for these projects.

This documentation indicates that Missouri is effectively using both pre- and post-disaster funding mechanisms and has been successful at securing annual allocations of mitigation funds in the nationally competitive Pre-Disaster Mitigation Grant Program. Since Missouri has an enhanced hazard mitigation plan, they receive 20 percent of post-disaster costs from the Hazard Mitigation Grant Program for mitigation purposes. Several project closeouts are also noted, indicating successful mitigation grant management. Section 6.2.1 Monitoring Implementation of Mitigation Measures and Project Closeouts provide details on individual project review and closeout procedures.

Table 4.4.5b HMGP Mitigation Project Summary Table 2002–2011

Hazard Mitigation Grant Program 2002	
Buried Lines	2
Buyouts	20
Safe Rooms	3
State 5% Initiative Projects	5
Total Projects	30
Number of Projects Closed/Completed*	30/0
Number of Projects Pending Closed/Completed**	0
Hazard Mitigation Grant Program 2003	
Buyouts	3
Water Lines	1
State 5% Initiative Projects	1
Total Projects	5
Number of Projects Closed/Completed*	5/0
Number of Projects Pending Closed/Completed**	0
Hazard Mitigation Grant Program 2004	
Safe Rooms	1
Total Projects	1
Number of Projects Closed/Completed*	1/0
Number of Projects Pending Closed/Completed**	0
Hazard Mitigation Grant Program 2006	
Buyout	1
Safe Rooms	11
Multipurpose Safe Rooms	1

Culvert	1
Low Water Crossing	5
Buried Lines	1
State 5% Initiative Projects	1
Total Projects	21
Number of Projects Closed/Completed*	0/3
Number of Projects Pending Closed/Completed**	18
Hazard Mitigation Grant Program 2007	
Buyouts	10
Safe Rooms	9
Buried Lines	1
State 5% Initiative Projects	1
Total Projects	21
Number of Projects Closed/Completed*	0/0
Number of Projects Pending Closed/Completed**	21
Hazard Mitigation Grant Program 2008	
Buyouts	5
Culvert	1
Saferoom	3
7% Planning	2
Total Projects	12
Number of Projects Closed/Completed*	1/6
Number of Projects Pending Closed/Completed**	5
Hazard Mitigation Grant Program 2009	
Buried Lines	1
Buyouts	1
Generator (State 5% Initiative Project)	1
Saferooms	27
7% Planning	3
Total Projects	33
Number of Projects Closed/Completed*	1/4
Number of Projects Pending Closed/Completed**	28
Hazard Mitigation Grant Program 2010	
Generator (State 5% Initiative Project)	1
Saferooms	2
Total Projects	3

umber of Projects Closed/Completed*	0/0
Number of Projects Pending Closed/Completed**	3
Hazard Mitigation Grant Program 2011	
Buyouts	2
Saferooms	57
Sirens (State 5% Initiative)	3
7% Planning	1
Total Projects	63
Number of Projects Closed/Completed*	0/0
Number of Projects Pending Closed/Completed**	63

Note:
* Number of projects closed are projects in which the final performance is complete as of June 5, 2013.
* Number of projects completed are projects in which all work is complete but the final performance report has not been approved as of June 5, 2013.
**Number of projects pending closed/completed are projects that have not completed their scope of work as of June 5, 2013.
Source: State Emergency Management Agency

Table 4.4.5c HMGP Pending Mitigation Project Summary Table 2006–2008

Pending Approval - Hazard Mitigation Grant Program 2006	
Multipurpose Safe Rooms	1
Total Projects Pending FEMA Approval*	1
Pending Approval - Hazard Mitigation Grant Program 2007	
Buyouts	5
Safe Rooms	2
Seismic Retrofit	1
Critical Facility	1
Total Projects Pending FEMA Approval*	9
Pending Approval - Hazard Mitigation Grant Program 2008	
Buyouts	1
Safe Rooms	5
Culvert	1
State 5% Initiative Projects	1
Total Projects Pending FEMA Approval*	8

Note: *Total Projects Pending FEMA Approval are projects submitted to SEMA but not approved by FEMA as of October 23, 2009.
Source: State Emergency Management Agency

Table 4.4.5c HMGP Pending Mitigation Project Summary Table 2009–2012

Pending Approval - Hazard Mitigation Grant Program 2011	
Bridge	1
Buyouts	4
Flood Control	2
Low Water Crossing	3
Saferooms	13
7% Planning	1
Total Projects	24
Number of Projects Closed/Completed*	0/0
Number of Projects Pending Closed/Completed**	24

Note: *Total Projects Pending FEMA Approval are projects submitted to SEMA but not approved by FEMA as of June 5, 2013.
Note: There are no projects pending approval from HMGP 2009 or 2010. There were no federal disaster declarations during 2012.
Source: State Emergency Management Agency

Table 4.4.5d FMA, RFC, and SRL Mitigation Project Summary Table 2004–2012

Flood Mitigation Assistance FY04, FY05, FY06, and FY08 through FY12	
Buyouts	3
Elevation	2
Total Projects	5
Number of Projects Closed/Completed*	4/0
Number of Projects Pending Closed/Completed**	1
Repetitive Flood Claims FY08 through FY12	
Buyouts	3
Total Projects	3
Number of Projects Closed/Completed*	2/0
Number of Projects Pending Closed/Completed**	1
Severe Repetitive Loss Program FY08 through FY12	
Buyouts	1
Total Projects	1
Number of Projects Closed/Completed*	0/1
Number of Projects Pending Closed/Completed	0

Note:
* Number of projects closed are projects in which the final performance is complete as of June 5, 2013.
* Number of projects completed are projects in which all work is complete but the final performance report has not been approved as of June 5, 2013.
**Number of projects pending closed/completed are projects that have not completed their scope of work as of October 23, 2009.
Source: State Emergency Management Agency

Table 4.4.5e PDM Mitigation Project Summary Table 2004–2009

Pre-Disaster Mitigation FY 2004	
Safe Rooms	2
Number of Projects Closed/Completed*	1/0
Number of Projects Pending Closed/Completed**	1
Pre-Disaster Mitigation FY 2005	
Bank Stabilization	2
Bridge Replacement	1
Buried Lines	1
Buyouts	2
Low Water Crossings	2
Safe Rooms	14
Total Projects	22
Number of Projects Closed/Completed*	20/0
Number of Projects Pending Closed/Completed**	2
Pre-Disaster Mitigation FY 2006	
Buried Lines	1
Safe Rooms	4
Total Projects	5
Number of Projects Closed/Completed*	1/3
Number of Projects Pending Closed/Completed**	1
Pre-Disaster Mitigation FY 2007	
Safe Rooms	12
Low Water Crossing	1
Total Projects	13
Number of Projects Closed/Completed*	0/0
Number of Projects Pending Closed/Completed**	13
Pre-Disaster Mitigation FY 2008	
Safe Rooms	1
Siren	2
Basin	1
Total Projects	4
Number of Projects Closed/Completed*	1/0
Number of Projects Pending Closed/Completed**	3
Pre-Disaster Mitigation FY 2009	

Safe Rooms	1
Total Projects	1
Number of Projects Closed/Completed*	0/0
Number of Projects Pending Closed/Completed*	1
Pre-Disaster Mitigation FY 2010	
Safe Rooms	1
Total Projects	1
Number of Projects Closed/Completed*	0/0
Number of Projects Pending Closed/Completed*	0
Legislative Pre-Disaster Mitigation FY2010	
Generators	1
Total Projects	1
Number of Projects Closed/Completed*	0/0
Number of Projects Pending Closed/Completed*	0
Pre-Disaster Mitigation FY 2011	
Safe Rooms	1
Total Projects	1
Number of Projects Closed/Completed*	0/0
Number of Projects Pending Closed/Completed*	0
Pre-Disaster Mitigation FY 2012	
Safe Rooms	1
Total Projects	1
Number of Projects Closed/Completed*	0/0
Number of Projects Pending Closed/Completed*	0

Note:
*Number of projects closed are projects in which the final performance is complete as of October 23, 2009.
*Number of projects completed are projects in which all work is complete but the final performance report has not been approved as of October 23, 2009.
**Number of projects pending closed/completed are projects that have not completed their scope of work as of October 23, 2009.
Source: State Emergency Management Agency
None of the non-disaster grants were funded by Congress for FY13 as of the date of this plan.

Prior to 2002, Missouri used mitigation funding for buyouts, elevations, and relocations; however, the nature of hazards in Missouri and types of mitigation projects broadened. Priority is still flood mitigation, but changes in threats have forced SEMA to broaden its perspective in mitigation projects. A list of mitigation projects dating back to 1993 can be accessed at this link to Past Mitigation Projects.

Since the last State plan update in 2010, the State has successfully completed and proposed buyout projects, tornado safe rooms, buried electrical lines, basin projects, and siren projects as listed in the tables above.

Progress in the remaining mitigation action categories, those not addressed in Table 4.4.5e, are summarized below. These action categories are more program- than project-related.

M1—State and Local Hazard Mitigation Plans: As of January 2013, 89 of 114 Missouri counties, had FEMA-approved hazard mitigation plans which altogether accounts for 94 percent of Missouri's population. These hazard mitigation plans that met the requirements of both the DMA 2000 and the Flood Mitigation Assistance Program. Another 28 counties (including the St Louis City) are in the process of updating their plan and/or in process of their first plan.

The implementation of local hazard mitigation plans through the assistance of the Regional Planning Commissions has been a major success story for Missouri's mitigation program. Not only are local communities more aware of what mitigation is and how it can benefit them, but the RPCs are more cognizant of integrating mitigation into other planning efforts, such as transportation and capital improvement plans. For more information, see Chapter 5 Coordination of Local Mitigation Planning.

M2—National Flood Insurance Program Floodplain Management and Community Rating System: Participation in the NFIP has increased between the publication of the 2010 plan and January 2013 (see Table 4.2.5a). There are an additional 28 communities in the program. As of January 2013, there were 652 NFIP participating jurisdictions: 650 communities in the regular program and 2 communities in the emergency program. All the participating communities have established local floodplain management ordinances to help them administer the program. Mitigation planning and the Pre-Disaster Mitigation grant program have had a positive impact on participation and interest in the NFIP. The program is expected to continue to grow. Many communities have had their current flood hazards mapped but have not yet joined the program.

Funds from a variety of programs have been used to develop flood maps for areas previously unmapped areas and to revise or update older existing maps. This initiative will enable more communities in the State to join the NFIP. In Missouri, FEMA's Risk Map program is ongoing and as January 2013, 80 jurisdictions (79 counties and the City of St. Louis. A map of the status of the DFIRM counties is in the levee discussion in Section 3.3.7 of Chapter 3.

M7—Earthquake/High Wind Nonstructural Mitigation Projects: No new projects were implemented between 2006 and 2013. Part of the reason is that there have been no recent earthquake events and there is an increased interest in tornado safe room projects because of recent tornado disasters.

M11—Technical Assistance: SEMA organized annual Pre-Disaster Mitigation (PDM) grant mentoring workshops, one each for the 2007, 2008, and 2009 grant cycles, to help local governments develop Electronic Grants (*e*Grants) (Hazard Mitigation Assistance subgrant applications) and to train them in benefit-cost. In 2009, SEMA actually hosted two workshops to train communities on the new benefit-cost analyses material. The workshops trained 50-60 local government representatives on their applications.

Sections 7.4 Assessment of Mitigation Actions and 7.5 Effective Use of Mitigation Funding provide additional examples of the progress and success of mitigation actions and programs.

4.4.6 Review and Integration with Local Actions

A roll-up and analysis of the mitigation actions contained in local plans was conducted to summarize the types of mitigation actions most commonly implemented, or desired to be implemented. This analysis included a summary of actions and the associated hazards, which give an indication of the priority hazards to be mitigated at the local level.

Methodology

The roll-up was conducted by reviewing and capturing key elements of the mitigation sections of each local plan into a master spreadsheet. Most local plans provided a summary table of their mitigation actions, which included a variety of information, such as action description, category of mitigation action, priority, responsible agency, potential funding sources, hazard addressed, and the action's relationship to the local plan's goals and objectives. Some local plans provided a limited amount of information that made it difficult to summarize their data.

The roll-up of the local mitigation actions focused on evaluating the types of local mitigation actions by determining the following:

- The total number of mitigation actions in each county
- The number of actions for each mitigation category (i.e., prevention, emergency services, property protection, natural resource protection, structural protection, and public information)
- The types of hazards addressed by each mitigation action

Most of this information was included in the mitigation action summary tables of the local plans. Additional information was obtained, where necessary, in the local plans' text. In some instances, where the mitigation categories as defined by the local plan did not meet the six FEMA-established mitigation categories included in FEMA state and local guidance, the actions were assigned to the most suitable FEMA category. In summary,

- 99 plans classified their projects into the six FEMA mitigation categories, and
- 26 plans classified their projects into other categories, in addition to the FEMA six.

This analysis assumes that the local actions were accurately placed in the FEMA mitigation categories, to the extent possible. There were instances where the action was not in the appropriate category, but no effort was made to try to reinterpret the information in the local plans. Some actions that are oriented to life safety, such as tornado safe rooms, do not easily fit into any of the six categories. Most assigned this action to structural projects.

Results

Table 4.4.6a summarizes the results of the roll-up of local mitigation actions using FEMA's mitigation categories. FEMA's publication *Developing the Mitigation Plan* emphasizes six categories of mitigation activities categories that are defined as follows:

- **Emergency Services:** Actions that protect people and property during and immediately after a disaster or hazard event.
- **Prevention:** Administrative or regulatory actions/processes that influence the way land and buildings are developed and built.

- **Public Education and Awareness:** Actions to inform and educate citizens, elected officials, and property owners about the hazards and potential ways to mitigation them.
- **Property Protection:** Actions that involve the modification of existing buildings or structures to protect them from a hazard or removal from the hazard area.
- **Natural Resource Protection:** Actions that, in addition to minimizing hazard losses, also preserve or restore the functions of natural systems.
- **Structural Projects:** Actions that involve the construction of structures to reduce the impact of hazard.

Table 4.4.6a Breakdown of Local Actions by Mitigation Categories

Mitigation Category	Percent
Emergency Services	18.7%
Prevention	22.3%
Public Information	25.0%
Property Protection	13.3%
Natural Resources	3.7%
Structural Projects	9.5%
Other	7.5%

Based on this summary, a large portion of the actions seemed to be policy and/or regulatory in nature. This means, they deal with influencing change on the front-end through community outreach efforts, policy changes, and developing and enforcing new regulations. Many of these fell into the emergency services, public information, and property protection categories showing that the full cycle of mitigation actions are needed at the local level.

4.4.7 Challenges in Implementation

In general, the State has been very successful in implementing mitigation projects. This is demonstrated in Section 7.2 Project Implementation Capability. Funding, or lack thereof, has been a major challenge in implementing mitigation projects in Missouri. Missouri has taken advantage of new grant programs, such as the Pre-Disaster Mitigation program, which provides annual allocations to fund both plans and projects. Missouri experience Presidential disasters frequently and as a result obtains significant Hazard Mitigation Grant Program funds. The fact that Missouri regularly experiences disasters presents its own special challenge, as SEMA mitigation staff are often involved in response and recovery operations in addition to mitigation program administration. Solutions to this challenge include developing innovative solutions for surge capacity backfill of SEMA mitigation staff. Currently this is accomplished through special contracts. The grant program has increased from around $25 million to approximately $100 million.

4.4.8 Mitigation Success

Mitigation successes are discussed in detail in Section 7.5 Effective Use of Available Mitigation Funding.

4.5 Funding Sources

Requirement §201.4(c)(3)(iv):	[The State mitigation strategy shall include an] identification of current and potential sources of federal, state, local, or private funding to implement mitigation activities.

Missouri uses a variety of sources to fund state and local mitigation activities. While most of the funding is from the federal government, additional funding comes from state and local government.

4.5.1 Primary Federal and State Funding

The State, through SEMA, has instituted an effective and comprehensive all-hazard mitigation program. Through a variety of programs, and the wise use of available federal and state funds, the State has been successful in mitigating areas against the devastating effects of disasters.

FEMA's hazard mitigation assistance programs are the primary sources of current funding for Missouri's mitigation activities. These programs are the Pre-Disaster Mitigation Program, Legislative Pre-Disaster Mitigation Program, Flood Mitigation Assistance Program, Hazard Mitigation Grant Program, Repetitive Flood Claims Grant, and Severe Repetitive Loss Program. SEMA also uses FEMA's Public Assistance Program (Categories C-G) to implement mitigation activities. All these grant programs are non-disaster (annually funded) grant programs except the HMGP and Public Assistance Program which are post-disaster programs. More detail on how this assistance was used since 2002 can be found in Section 4.4.5 Review and Progress of Mitigation Actions. The Repetitive Flood Claims Program and the Severe Repetitive Loss Programs are newer FEMA funding sources that Missouri is beginning to use. All of these programs are discussed further in the following pages.

Pre-Disaster Mitigation Program

Program Summary: The Pre-Disaster Mitigation (PDM) program is a FEMA grant program. In 2009, Congress amended the Robert T. Stafford Disaster Relief and Emergency Assistance Act to reauthorize the pre-disaster mitigation program of FEMA. In addition, there is the Legislative Pre-Disaster Mitigation (L-PDM) program funded through the National Legislative Pre-Disaster Mitigation Fund. The purpose of PDM and L-PDM programs are to provide funds to states, territories, Indian tribal governments, and communities for hazard mitigation planning and the implementation of mitigation projects prior to a disaster event. Funding these plans and projects reduces overall risks to the population and structures, while also reducing reliance on funding from actual disaster declarations.

Project grants are available for voluntary acquisition of real property (i.e., structures and land, where necessary) for open space conversion; relocation of public or private structures; elevation of existing public or private structures to avoid flooding; structural and nonstructural retrofitting of existing public or private structures to meet/exceed applicable building codes; construction of safe rooms for public and private structures; vegetation management (e.g., for wildfire); protective measures for utilities, water and sanitary sewer systems, and infrastructure; storm water management projects; and localized flood control projects that are designed specifically to protect critical facilities and that do not constitute a section of a larger flood control system.

Planning grants are available for new plan development, plan upgrades, and comprehensive plan reviews and updates.

Amount: Congress appropriated $50 million for this program for fiscal year 2011. Each State will receive at least $575,000 or the amount that is equal to one percent of the total funds appropriated to carry out this section for the fiscal year.

PDM grants are awarded on a competitive basis. Eligible subapplications will compete nationally for PDM grant funds.

Eligibility: In Missouri, SEMA serves as the applicant for all PDM and L-PDM grants. State-level agencies, including state institutions (e.g., state hospital or university); federally recognized Indian tribal governments; local governments (including state recognized Indian tribes and authorized Indian tribal organizations); public colleges and universities; and Indian Tribal colleges and universities are eligible to apply to SEMA for assistance as subapplicants. Private nonprofit organizations and private colleges and universities are not eligible to apply to the State, but an eligible, relevant state agency or local government may apply on their behalf. SEMA reviews and prioritizes subapplications and submits the grant application with subapplications to FEMA for review and approval.

All subapplicants that have been identified through the NFIP as having a Special Flood Hazard Area and that have a Flood Hazard Boundary Map or a Flood Insurance Rate Map must be participating and in good standing in the NFIP. There is no NFIP participation requirement for PDM and HMGP project subapplications for projects located outside of the SFHA. Also there are no NFIP participation requirements for PDM and HMGP hazard mitigation planning subapplications. The latest Hazard Mitigation Assistance Unified Guidance can also provide the latest information.

For project grants, subapplicants must have a FEMA-approved local mitigation plan. All activities submitted for consideration must be consistent with the local mitigation plan as well as the Missouri State Hazard Mitigation Plan.

Cost-Share Requirements: PDM and L-PDM grants are provided on a 75 percent federal/25 percent nonfederal cost share basis. Small and impoverished communities may be eligible for up to a 90 percent federal cost-share (see Section 5.3.3 Small and Impoverished Communities).

Requirements: Recipients of PDM and L-PDM planning grants must produce FEMA-approved hazard mitigation plans.

More Information:

Pre-Disaster Mitigation Program - www.fema.gov/government/grant/pdm/index.shtm and Hazard Mitigation Assistance (HMA) Unified Guidance http://www.fema.gov/library/

SEMA
(573) 526-9100
http://sema.dps.mo.gov/Mitigation.htm

FEMA Region VII
(816) 283-7061
www.fema.gov/about/contact/regionvii.shtm

SEMA Fund Administrator: Logistics, Resources, Mitigation and Floodplain Management Branch, State Hazard Mitigation Officer

Flood Mitigation Assistance Program

Program Summary: The Flood Mitigation Assistance Program (FMA) is a program under FEMA's NFIP. Its purpose is to implement cost-effective measures that reduce or eliminate the long-term risk of flood damage to buildings, manufactured homes, and other structures insured under the NFIP. The FMA provides planning grants for communities to assess their flood risk and identify actions to reduce it. Planning grants may be used to develop a new or update an existing flood mitigation plan (this also applies to the flood hazard portion of multi-hazard mitigation plans).

Project grants are available for acquisition, structure demolition, or structure relocation with the property deed restricted for open space uses in perpetuity; elevation of structures; dry floodproofing of nonresidential structures; and minor structural flood control activities.

Planning grants are available for flood mitigation planning activities.

Amount: For fiscal year 2009 (October 1, 2008-September 30, 2009), Congress appropriated $35.7 million for the FMA and Missouri received $540,200 ($498,600 for projects and $41,600 for planning). For fiscal year 2010, Congress has appropriated $40 million.

Eligibility: In Missouri, SEMA serves as the applicant for all FMA grants. State-level agencies, federally recognized Indian tribal governments, and local governments (including state-recognized Indian tribes and authorized Indian tribal organizations) are eligible to apply to SEMA for assistance as subapplicants. Individuals and private nonprofit organizations are not eligible to apply to the State, but a relevant state agency or local community may apply on their behalf. SEMA reviews and prioritizes subapplications by the applications that include mitigating repetitive loss properties. SEMA then submits the grant application with subapplications to FEMA for review and approval.

All subapplicants must be participating and in good standing in the NFIP. Also properties included in a project subapplication must be NFIP-insured at the time of the application submittal.

For project grants, subapplicants must have a FEMA-approved flood mitigation plan or multi-hazard mitigation plan that meets FMA planning requirements. All activities submitted for consideration must be consistent with the local mitigation plan as well as the Missouri State Hazard Mitigation Plan.

Cost-Share Requirements: FMA funds are provided on a 75 percent federal/25 percent nonfederal cost share basis. The recipient must provide the 25 percent match, only half of which may be in-kind contributions. For severe repetitive loss properties, FEMA will contribute up to 90 percent of the total eligible costs if the State has taken actions to reduce the number of severe repetitive loss properties and has an approved state mitigation plan that specifies how it intends to reduce the number of severe repetitive loss properties.

Requirements: Recipients of FMA planning grants must produce FEMA-approved flood mitigation plans.

More Information:

Flood Mitigation Assistance (FMA) Program
http://www.fema.gov/flood-mitigation-assistance-program and Hazard Mitigation Assistance (HMA) Unified Guidance http://www.fema.gov/library/

SEMA
(573) 526-9100
http://sema.dps.mo.gov/Mitigation.htm

FEMA Region VII
(816) 283-7061
www.fema.gov/about/contact/regionvii.shtm

SEMA Fund Administrator:

Logistics, Resources, Mitigation and Floodplain Management Branch, State Hazard Mitigation Officer

Hazard Mitigation Grant Program

Program Summary: The Hazard Mitigation Grant Program (HMGP) is a FEMA program to provide funds to states, territories, Indian tribal governments, and communities to significantly reduce or permanently eliminate future risk to lives and property from natural hazards. HMGP funds projects in accordance with priorities identified in state, tribal, or local hazard mitigation plans, and enables mitigation measures to be implemented during the recovery from a disaster.

HMGP funds can be used for projects to protect either public or private property, as long as the project fits within state and local government mitigation strategies to address areas of risk and complies with program guidelines. Examples of projects include acquiring and relocating structures from hazard-prone areas; retrofitting structures to protect them from floods, high winds, earthquakes, or other natural

hazards; constructing certain types of minor and localized flood control projects; and constructing safe rooms inside schools or other buildings in tornado-prone areas.

The State may set aside up to 7 percent of the HMGP funds received following a presidential disaster declaration to develop FEMA-approved mitigation plans. The State may also set aside up to 5 percent of the HMGP monies to fund the State 5 percent Initiative Projects (see Section 4.4.1: Actions (Projects) That Will Be Considered by the State of Missouri).

Amount: Federal funding under the HMGP is available following a major disaster declaration if requested by the governor. The amount of an HMGP grant will depend on the costs associated with each individual disaster. Since the Missouri State Hazard Mitigation Plan is an enhanced plan, the State is eligible for up to 20 percent of the total estimated federal assistance provided after a major disaster declaration. States with standard hazard mitigation plans are eligible for 15 percent for amounts not more than $2 billion, 10 percent for amounts of more than $2 billion and not more than $10 billion, and 7.5 percent on amounts more than $10 billion and not more than $35.3 billion.

Eligibility: HMGP funds are administered by SEMA. Local governments, eligible private non-profit organizations or institutions, and Indian tribes or authorized tribal organizations are eligible to apply to SEMA for assistance as subapplicants. Individuals and businesses are not eligible to apply to the State, but eligible local governments or private non-profit organizations may apply on their behalf.

SEMA's administrative plan for ten federal disasters starting with DR-1736 in December 2007, says that the Mitigation Section reviews the submitted HMGP subapplications documents. Priority is given to flood mitigation, tornado/ severe wind, ice storm and earthquake mitigation projects located in the declared counties. If all available funds are not expended on these mitigation projects, consideration will be given to other types of mitigation projects in the declared counties prior to requesting proposals statewide. The subapplications are sent to FEMA for review and approval.

For project grants, subapplicants must have a FEMA-approved local mitigation plan. All activities submitted for consideration must be consistent with the local mitigation plan as well as the Missouri State Hazard Mitigation Plan.

Cost-Share Requirements: HMGP funds are provided on a 75 percent federal/25 percent nonfederal cost share basis. The nonfederal match does not does not need to be cash; in-kind services and/or materials may be used.

More Information:

Hazard Mitigation Grant Program
www.fema.gov/government/grant/hmgp/index.shtm and Hazard Mitigation Assistance (HMA) Unified Guidance http://www.fema.gov/library/

SEMA
(573) 526-9100
http://sema.dps.mo.gov/Mitigation.htm

FEMA Region VII
(816) 283-7061
www.fema.gov/about/contact/regionvii.shtm

SEMA Fund Administrator: Logistics, Resources, Mitigation and Floodplain Management Branch, State Hazard Mitigation Officer

Repetitive Flood Claims Program

Program Summary: The Repetitive Flood Claims (RFC) Program is a FEMA program designed to reduce or eliminate the long-term risk of flood damage to structures insured under the NFIP that have had one or more claim payment(s) for flood damage.

Project grants are available for voluntary property acquisition, structure demolition, structure elevation, dry floodproofing of structures, and minor localized flood reduction projects. If the structure is removed, the property is deeded to the community and restricted only to open-space use. The property can never be developed again.

Planning grants and non-flood hazard mitigation activities are not available.

Amount: Historically, Congress appropriated $10 million for the RFC program for each fiscal year 2006-2012. RFC grants are awarded nationally without reference to state allocations, quotas, or other formula-based allocation(s) of funds.

Eligibility: RFC funds can only be used mitigate structures that are located within a state or community that cannot meet the requirements of the FMA for either cost share or capacity to manage the activities.

In Missouri, SEMA serves as the applicant for all RFC grants. State-level agencies, federally recognized Indian tribal governments, and local governments (including state-recognized Indian tribes and authorized Indian tribal organizations) are eligible to apply to SEMA for assistance as subapplicants. Individuals and private nonprofit organizations are not eligible to apply to the State, but a relevant state agency or local community may apply on their behalf. SEMA reviews and prioritizes subapplications and submits the grant application with subapplications to FEMA for review and approval.

All subapplicants must be participating and in good standing in the NFIP.

Cost-Share Requirements: All RFC grants are eligible for up to 100 percent federal assistance.

More Information:

Repetitive Flood Claims Program
www.fema.gov/government/grant/rfc/index.shtm and Hazard Mitigation Assistance (HMA) Unified Guidance http://www.fema.gov/library/

SEMA
(573) 526-9100
http://sema.dps.mo.gov/Mitigation.htm

FEMA Region VII
(816) 283-7061
www.fema.gov/about/contact/regionvii.shtm

SEMA Fund Administrator: Logistics, Resources, Mitigation and Floodplain Management Branch, State Hazard Mitigation Officer

Severe Repetitive Loss Program

Program Summary: The Severe Repetitive Loss (SRL) program is a FEMA program with a purpose to reduce or eliminate the long-term risk of flood damage to severe repetitive loss residential properties and the associated drain on the National Flood Insurance Fund (NFIF) from such properties. FEMA defines SRL properties as residential properties that have at least four NFIP claim payments over $5,000 each, at least two of which occurred within any ten-year period, and the cumulative amount of such claims payments exceeds $20,000; or that have at least two separate claims payments (building payments only) where the total of the payments exceeds the value of the property, when two such claims have occurred within any ten-year period.

Project grants are available for flood mitigation activities such as acquisition, structure demolition, or structure relocation with the property deed restricted for open-space uses in perpetuity; elevation of structures; floodproofing of structures; minor physical localized flood control projects; and mitigation reconstruction. SEMA gives the highest priority to the subapplicant projects that demonstrate the greatest savings to the NFIF based on a benefit cost ratio.

Planning grants are not available.

Amount: The SRL program was authorized for up to $40 million for fiscal years 2006 and 2007. Then up to $80 million in fiscal years 2008 and 2009 and $70 million in fiscal year 2010. The SRL program is subject to the availability of appropriation funding, as well as any directive or restriction made with respect to such funds.

Eligibility: In Missouri, SEMA serves as the applicant for all SRL grants. State-level agencies, federally recognized Indian tribal governments, and local governments (including state-recognized Indian tribes and authorized Indian tribal organizations) are eligible to apply to SEMA for assistance as subapplicants. Individuals and private nonprofit organizations are not eligible to apply to the State, but a relevant state agency or local community may apply on their behalf. SEMA reviews and prioritizes subapplications and submits the grant application with subapplications to FEMA for review and approval.

All subapplicants must be participating and in good standing in the NFIP and an approved local mitigation plan is required.

Cost-Share Requirements: SRL grants are provided on a 75 percent federal/25 percent nonfederal cost share basis. Up to 90 percent federal cost-share funding may be available for projects approved in states, territories, and federally recognized Indian Tribes with FEMA-approved standard or enhanced mitigation plans or Indian tribal plans that include a repetitive loss strategy for mitigating existing and future SRL properties.

More Information:

Severe Repetitive Loss Program
www.fema.gov/government/grant/srl/index.shtm and Hazard Mitigation Assistance (HMA) Unified Guidance http://www.fema.gov/library/

SEMA
(573) 526-9100
http://sema.dps.mo.gov/Mitigation.htm

FEMA Region VII
(816) 283-7061
www.fema.gov/about/contact/regionvii.shtm

SEMA Fund Administrator: Logistics, Resources, Mitigation and Floodplain Management Branch, State Hazard Mitigation Officer

FEMA's Public Assistance—Mitigation

Program Summary: Section 406 (Public Assistance) of the Stafford Act establishes the program for the repair, restoration, and replacement of facilities damaged as a result of a presidentially declared disaster. These funds can also be used for hazard mitigation measures a state or local government determines to be necessary to meet a need for governmental services and functions in the area affected by the major disaster. Section 406 mitigation funds can only be used in the declared disaster areas (usually counties) and only in conjunction with identified, eligible disaster projects that will strengthen existing infrastructure and facilities to more effectively withstand the next disaster. One example would be replacing a blown out culvert with one designed to convey higher flows, instead of one that will be easily damaged in a flood again.

Eligibility: State-level agencies, federally recognized Indian tribal governments, and local governments (including state-recognized Indian tribes and authorized Indian tribal organizations) are eligible to apply to SEMA for assistance.

Cost-Share Requirements: Public Assistance grants are provided at not less than 75 percent federal/25 percent nonfederal cost share basis for emergency measures and permanent restoration. All projects approved under State disaster assistance grants will be subject to the cost sharing provisions established in the FEMA-State Agreement and the Stafford Act.

More Information:

FEMA's Public Assistance Program
http://www.fema.gov/plan/ehp/noma/projects2.shtm

SEMA
(573) 526-9100
http://sema.dps.mo.gov/

FEMA Region VII
(816) 283-7061
www.fema.gov/about/contact/regionvii.shtm

SEMA Fund Administrator: Planning & Disaster Recovery Branch, PDR Branch Manager

Other Sources of Federal and State Funding and Technical Assistance

Additional sources of federal and state funding and technical assistance can be found at this link which is a resource for all state, regional, and local planners trying to find funding for their mitigation action. Funding Assistance Programs are separated into the following categories:

- General emergency management grants, loans, and assistance;
- Floods/flood control grants, loans, and technical assistance;
- Earthquake grants, loans, and technical assistance;
- All-hazard mapping grants, loans, and technical assistance;
- Ancillary flood and natural resource projects grants, loans, and technical assistance;
- Basic and applied research/development grants; and
- Other planning resources: Demographics, societal data, and transportation, agricultural, industrial, and economic statistics.

Please note that there is discussion regarding modifying these programs, however, at the time of this publication, the modification has not been established.

4.5.2 Local Funding

Local governments receive most of their funding for mitigation projects from the federal programs discussed above. Sources of local funding include tax-funded investments (predominantly from property and sales tax) in infrastructure improvements and dedicated transportation/capital improvements sales or use taxes, all of which can also serve to mitigate hazards. A sales tax or bond issue to fund mitigation would require a vote of residents and could be difficult to pass. More information about local funding can be found in Section 4.3.2 Local Policies, Programs, and Capabilities and Section 7.5 Effective Use of Available Mitigation Funding.

4.6 Severe Repetitive Flood Loss Strategy

Requirement §201.4(c)(3)(v):	A State may request the reduced cost share authorized under §79.4(c)(2) of this chapter for the FMA and SRL programs, if it has an approved State Mitigation Plan... that also identified specific actions the State has taken to reduce the number of repetitive loss properties (which **must** include severe repetitive loss properties), and specifies how the State intends to reduce the number of such repetitive loss properties.

A high priority in Missouri is their Severe Repetitive Flood Loss Strategy and how it reduces losses to repetitive loss structures. These structures drain the National Flood Insurance Fund (NFIF). They increase the NFIP's annual losses and the need for additional borrowing. More importantly, they take away resources needed to prepare for catastrophic events. The NFIP defines a repetitive loss property as "any insurable building for which two or more claims of more than $1,000 were paid by the NFIP within any rolling 10-year period, since 1978. At least two of the claims must be more than 10-days apart."

The Flood Insurance Reform Act of 2004 identified another category of repetitive loss, called severe repetitive loss, and defined it as "a single family property (consisting of one-to-four residences) that is covered under flood insurance by the NFIP and has incurred flood-related damage for which four or more separate flood insurance claim payments have been paid under flood insurance coverage with the amount of each claim payment exceeding $5,000 and with cumulative amount of such claims payments exceeding $20,000; or for which at least two separate NFIP claim payments have been made with the cumulative amount of such claims exceeding the reported value of that property."

The Severe Repetitive Flood Loss Strategy is based on the State Risk Assessment and the State addressing repetitive flood loss structures in its risk assessment. For example, in Section 3.5.8, Riverine Flooding, Flood Insurance Claims Analysis and Repetitive Loss and Severe Repetitive Loss Property Analysis, the State analyzed NFIP flood-loss data to determine areas of Missouri with the greatest flood risk. It includes a target list of repetitive loss properties and map by county in Missouri. It also ranks the number of losses by county and shows loss ratio. A severe repetitive loss property summary is provided by county and the number of SRL properties in those counties.

4.6.1 State Mitigation Goals that Support Reducing Repetitive Flood Loss Properties

This strategy is supported with the State Mitigation Goals restated below by reducing repetitive flood loss properties. Goal 1 and Goal 3 both support the development and funding of sensible mitigation projects to eliminate repetitive flood losses. Goal 4 supports the Community Buyout Program by creating deed restricted open space areas that emergency services do not have to respond and rescue people.

> Goal 1: Implement mitigation actions that improve the protection of human life, health, and safety from the adverse effects of disasters.

Goal 2: Implement mitigation actions that improve the continuity of government and essential services from the adverse effects of disasters.

Goal 3: Implement mitigation actions that improve the protection of public and private property from the adverse effects of disasters.

Goal 4: Implement mitigation actions that improve the protection of community tranquility from the adverse effects of disasters.

4.6.2 State Hazard Mitigation Capabilities, Programs, and Policies that Support Reducing Repetitive Flood Loss Properties

In Section 4.2.1 State Agencies and Mitigation-Related Programs and Initiatives discusses the State's Community Buyout Program that has been successful since the Great Flood of 1993 and continues to be a priority for mitigation funding in Missouri. It also states that repetitive flood loss properties are a priority under this program.

The State Hazard Mitigation Officer (SHMO) has direct access to Bureau Net spreadsheets listing the repetitive loss (RL) properties and the severe repetitive loss (SRL) properties by address in Missouri. The SHMO uses these spreadsheets to track the mitigated and non-mitigated properties and thus supporting the Severe Repetitive Flood Loss Strategy. These Bureau Net spreadsheets are further used by the Mitigation Planner dedicated to assisting the local planners. The Mitigation Planner sends the list of RL & SRL properties with a privacy act disclaimer to the local planners. This Planner also double checks their information in the county-level draft plans against the Bureau Net spreadsheets to ensure accuracy.

In addition, the SHMO sends out Notice of Interest letters after the presidential disaster declarations notifying counties of the availability of HMGP. Where applicable, this letter also alerts the local elected officials that there are RL & SLR properties within their community and describes these properties as a priority for the volunteer buyout program in Missouri. Additional details concerning the SHMO duties and the mitigation planners' duties are discussed in Section 6.2.3 Staffing.

Local community mitigation plans discuss and address their repetitive flood loss properties. SEMA encourages local community mitigation plans to turn their discussion of repetitive loss properties into more local mitigation actions to further reduce the number of repetitive loss properties in the State.

4.6.3 State Mitigation Actions that Support Reducing Repetitive Flood Loss Properties

In Section 4.4 Mitigation Actions, category M3—Voluntary Property Acquisitions discusses that one of SEMA's top priorities is repetitive flood loss structures and severe repetitive loss properties. This is supported by the amount of obligated funds for flood buyout projects from 2002-2009. There were 43 buyout projects throughout Missouri totaling over $24 million in that timeframe.

4.6.4 Specific Implemented Actions that Support Reducing Repetitive Flood Loss Properties

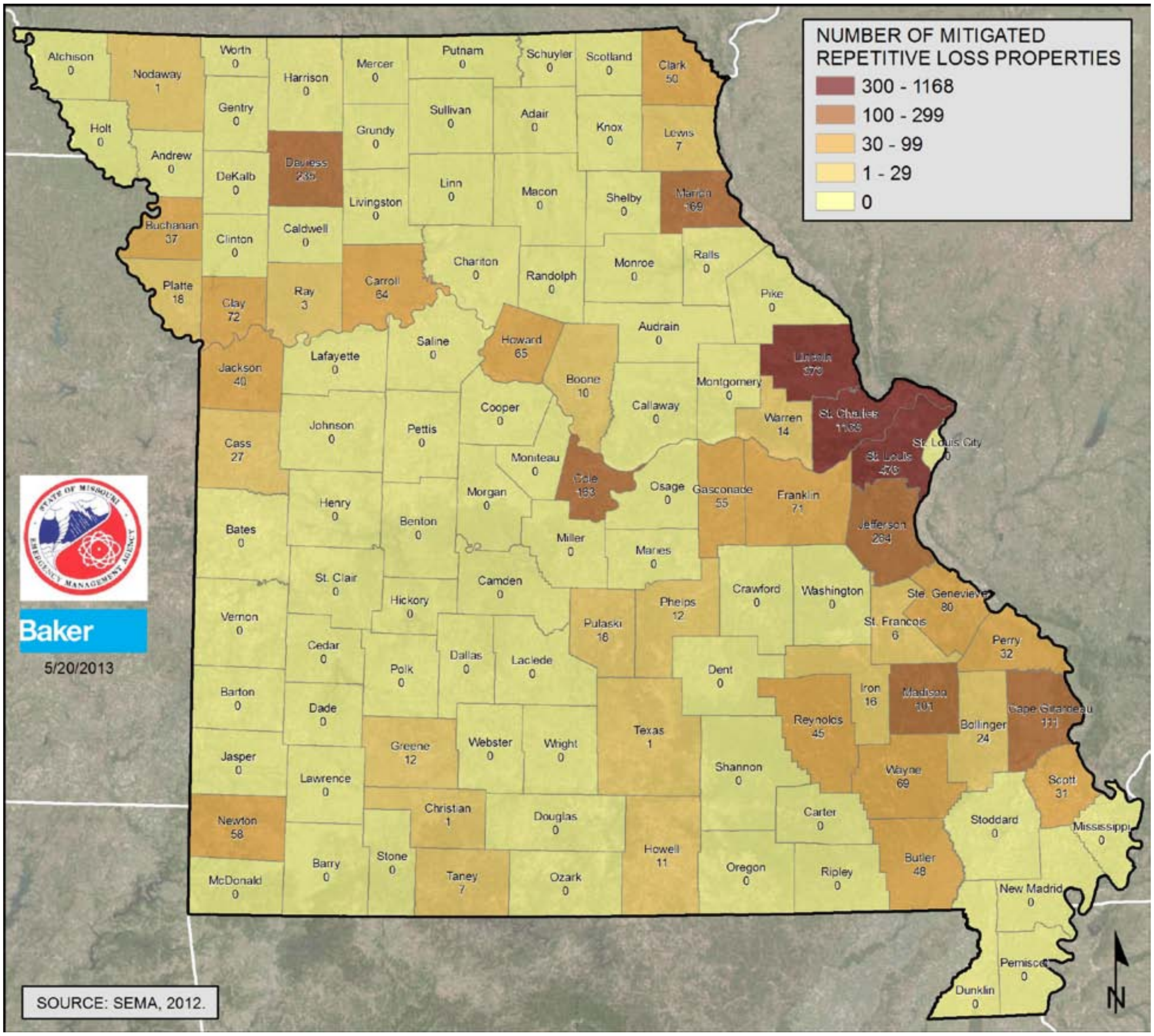
In Missouri, there are 3,058 repetitive flood loss properties as of November 2009. Of those 3,058, Missouri has already mitigated 1,736 since implementing the State's Community Buyout Program. That

is a huge accomplished as over half the repetitive flood loss properties have already been taken out of the harm's way and the flood damage cycle.

There are numerous communities that can be highlighted that have aggressively bought out repetitive flood loss structures. In particular, the City of Arnold had purchased 202 single family dwellings and 155 mobile home pads on the floodplain by the end of 1995. Then they also worked to purchase nine additional homes that had four or more repetitive loss claims paid by NFIP totaling $961,846 by 1995. That represents 43 flood claims, for an average of 4.77 flood claims per property, over roughly a 16 year period. In seven of the nine properties, the NFIP claims paid had already exceeded the fair market value of the properties. In three of those cases, the NFIP claims paid were close to double the fair market value of the properties. Based on those statistics only, it is possible that the entire $840,000 project cost will be recouped by the NFIP savings within the next 15-20 years.

Figure 4.6.4.1 below is a Missouri map of the 1,736 RL properties that have been mitigated with HMA funds. Most of the mitigated properties are along the Mississippi River and Missouri River corridors. St. Charles County and St. Louis County have the largest number of properties acquired with over 600 mitigated properties in each county.

Figure 4.6.4.1 - The 1,736 Mitigated Repetitive Flood Loss Properties (HMA Funded)



In Missouri, there are also 159 SRL properties with 25 of them already mitigated. Table 4.6.4a below shows the mitigated properties are located in five Missouri counties. The far right column in the table lists the "savings to the fund". This is the value (benefit) to the NFIF of mitigating those properties. It is the product of an actuarial analysis of expected claims and anticipated premium collection. Thus almost $4 million has been saved in the NFIF so far in Missouri.

Table 4.6.4a Mitigated Severe Repetitive Loss Properties by County

County	# of Mitigated SRL Properties	Savings to the Fund
Holt	1	$205,634
Jefferson	2	$191,431
Lincoln	1	$98,657
St. Charles	9	$1,866,863
St. Louis	12	$1,512,400
Totals	**25**	**$3,874,985**

Source: BureauNet, December 2009

4.6.5 Funding that Supports Reducing Repetitive Flood Loss Properties

In Section 4.4.5 Review and Progress of Mitigation Actions highlights the yearly funding programs, types of projects, and amounts. Several funding sources have been used for the flood buyout projects: HMGP, FMA, RFC, SRL, and PDM.

SEMA also has a list of questions to help prioritize the distribution of mitigation project funds to local communities in Section 5.3.2 Project Grants. One bullet item states, "does the project result in mitigating flood damage to repetitive loss or severe repetitive loss properties." Thus the State does take RL & SRL communities into consideration when prioritizing local project funding. Also, the communities with multiple repetitive loss structures are the communities that usually pursue grant funding first.

CDBG funds and the Disaster Recovery Supplemental CDBG are also used in Missouri to fund the State's Community Buyout Program and support reducing repetitive flood loss properties. CDBG funds are used to voluntarily buyout residential and non-residential properties.

***Technical Note**: This document is a User Interfaced, Web Based Interactive Document. It has been formatted with active embedded hyperlinks throughout. There are several different types of hyperlinks. Hyperlinks within the document: Some of the hyperlinks will direct the user to specific sections of the plan where referenced information may be found. These links are identified by a blue color format.*

Hyperlinks to SEMA website: Some of the hyperlinks will direct the user to a SEMA website to access reference documents and resource data. Some of these documents are password protected and the user will be directed to obtain credentials from SEMA to gain access. These links are identified by a red color format.

Hyperlinks to external websites: These hyperlinks will direct the user to a third party website where additional information can be found. As with all hyperlinks to external sites, if the site administrator makes changes to the URL, these can expire or become non-functional. These links are identified by a green color format.

This chapter focuses on three aspects of the State's involvement in local mitigation planning. The section heading hyperlinks provided below, allow you to go to a specific sub-section of Chapter 5:

5.1 Local Funding and Technical Assistance

Requirement §201.4(c)(4)(i):	[The section on the coordination of local mitigation planning must include a] description of the State process to support, through funding and technical assistance, the development of local mitigation plans.

5.1.1 Background

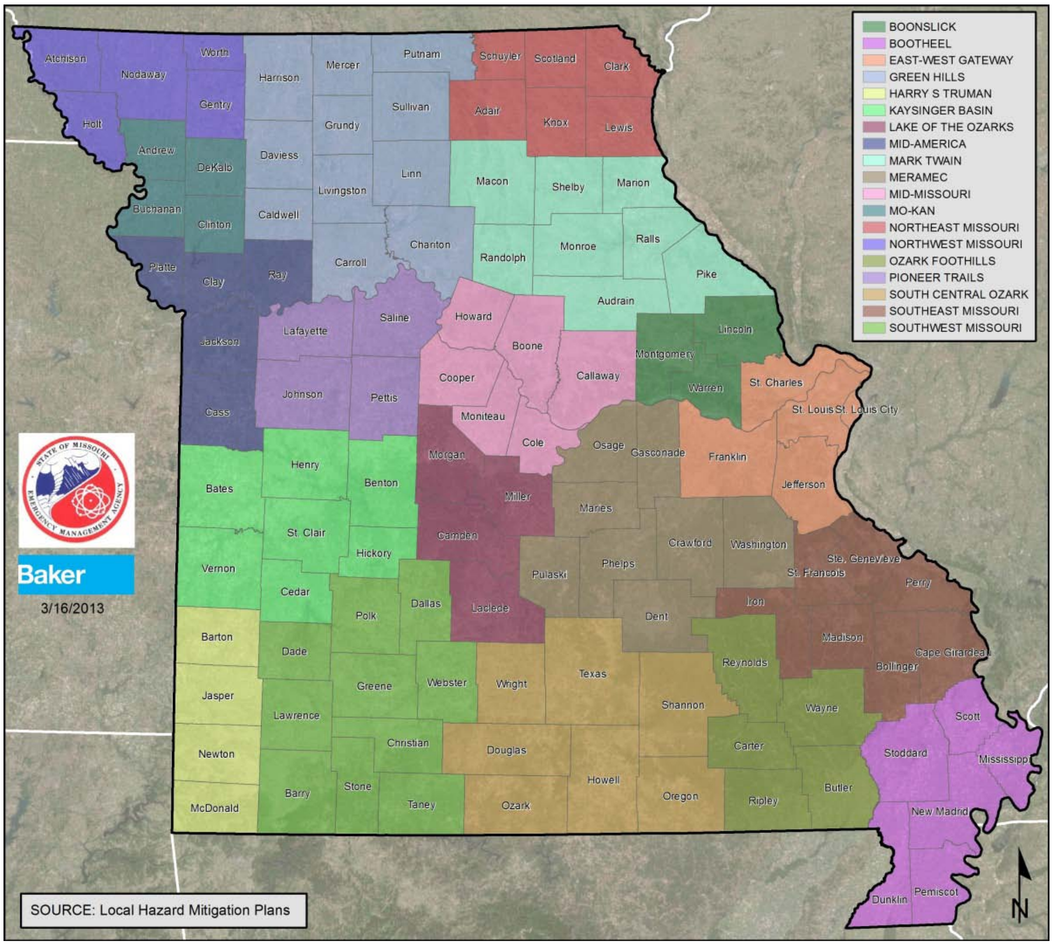
Per DMA 2000, all local governments must have a hazard mitigation plan approved by FEMA to receive project grants from the HMGP, Pre-Disaster Mitigation Program, and Severe Repetitive Loss Program. An approved flood mitigation plan (which may be part of an approved multi-hazard plan) is required for the Flood Mitigation Assistance Program. (The Repetitive Flood Claims Program does not currently require a local hazard mitigation plan). It is the role of the State to provide assistance to local governments for plan development and to ultimately use the local plans to improve the statewide plan.

When the 2004 version of the Missouri State Hazard Mitigation Plan was being compiled, local community mitigation plans were largely unavailable and local community information was limited. Now, through the 2007, 2010 and 2013updates, the local community information continues to improve. Back in 2004, SEMA's Logistics, Resources, Mitigation and Floodplain Management Branch reviewed all the options and decided to contact the Missouri Association of Councils of Government, the umbrella organization for Missouri's 19 Regional Planning Commissions/Councils of Government (RPCs) (see

Figure 5.1.1.1), for help with the development of multi-jurisdictional county-level plans. This is still the process for the development or updates to the multi-jurisdictional county-level plans. With guidance and prioritization (see Section 5.3 Prioritizing Local Assistance) from SEMA, RPCs were asked to develop mitigation plans for the counties in their region that would:

- Meet the requirements of DMA 2000 for local hazard mitigation plans
- Include the unincorporated and incorporated parts of the county, regardless of population
- Specifically address natural hazards and mitigation strategies and initiatives for each incorporated jurisdiction

Figure 5.1.1.1 - Missouri Regional Planning Councils



As a result of two presidentially declared disasters in 2002 (DR 1403 and DR 1412) and one in 2003 (DR 1463), SEMA had a limited amount of planning funds that they allocated to fund the RPCs' local hazard mitigation planning efforts. Counties that did not receive initial funding were provided with planning documents, guidance, and information from SEMA's Logistics, Resources, Mitigation and Floodplain Management Branch. As more funding for planning becomes available, SEMA uses a list of questions to help prioritize how best to distribute the funds (see Section 5.3 Prioritizing Local Assistance).

Additional guidance was also issued by SEMA during this period concerning the integration of other potential grant applicants (CFR 201.2 Definitions) into the local multi-jurisdictional hazard mitigation

plans. Jurisdictions can be the county, municipality, city, town, township, public authority, school district, special district, intrastate district, councils of government, Indian tribe or other public entity.
A significant accomplishment of SEMA was the addition of a Mitigation Planner in November of 2007. This planner is available to providing technical assistance with local mitigation plan projects. With this Mitigation Planner, the overall effectiveness of the local plans has increased. The Mitigation Planner is able to give the local RPC planners ideas for specific hazards data, sample vulnerability analysis based on available data for their area, thus creating a more detailed local multi-hazard mitigation plan particularly for more vulnerable jurisdictions (i.e. highly populated communities).

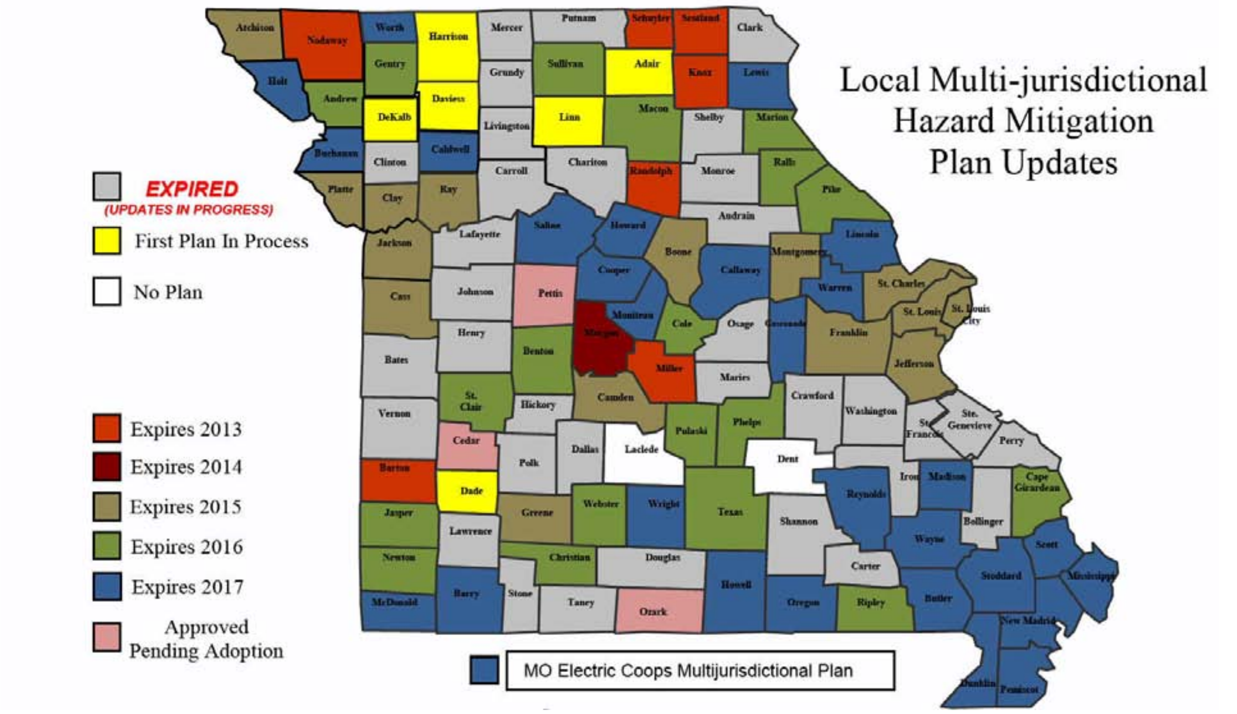
5.1.2 Local Plan Development Status

As of May 2013, 78 of the 115 Missouri counties (plus the City of St. Louis) had FEMA-approved hazard mitigation plans that met the requirements of both the DMA 2000 and the Flood Mitigation Assistance Program. Another 32 counties are in the process of updating their plan and/or in process of their first plan (see Figure 5.1.2.1). Please note that the Electric Coops Multijurisdictional Plan is shown in Blue on this Figure because it is set to expire in 2017.

With many county-level plans available, SEMA can effectively coordinate its efforts with local jurisdictions and assess how to most efficiently distribute project funding and technical assistance. Section 5.1.3 describes the process the State uses to provide planning support to local jurisdictions and the types of funding and technical assistance they make available for initial and future planning efforts.
A list of the Approved Local Hazard Mitigation Plans State List and FEMA list is available on SEMA's website http://sema.dps.mo.gov/programs/mitigation_management.asp under Local Hazard Mitigation Plan Information. All of the jurisdictions in Missouri that are covered by a plan, their original approval dates, and their proposed completion dates for the update is included. Other jurisdictions included in county-level plans that are not cities, towns, or villages include various public colleges along with several public school districts. This link provides access to all local hazard mitigation plans in Missouri that have been approved by FEMA.

Associated Electric Cooperative, Inc. (AECI) was established in 1961 to provide wholesale power generation and transmission to its member-owners. Associated is owned by and provides wholesale power to six regional generation and transmission cooperatives (G & Ts). In turn, these six regional generation and transmission cooperatives are owned by and provide wholesale power to 51 local electric cooperative systems (distribution cooperatives) in Missouri, southeast Iowa and northeast Oklahoma. The organization provides power for more than 875,000 customers in three states. For more information go to: http://www.aeci.org/

Figure 5.1.2.1 - Local Mitigation Plan Status by County, May 2013



Source: SEMA website, May 2013

5.1.3 Process to Provide Local Assistance

Most jurisdictions require some form of assistance to develop and update their local hazard mitigation plans (FEMA requires that local plans be updated every five years, but plans may be updated more frequently if needed—e.g., after a major disaster). Since funding for planning purposes is generally minimal, and SEMA is unable to provide planning funds to every jurisdiction that requires a local hazard mitigation plan, technical support is the primary method that SEMA uses to provide planning assistance to local jurisdictions.

Although most Missouri counties now have a FEMA-approved hazard mitigation plan or are in the update process, SEMA continues to work with the RPCs to provide assistance to those that do not yet have a plan in place. Most of the remaining counties are currently in the plan development stage or have funding sources identified (e.g., HMGP, PDM, local funds) to assist in developing the plan. Numerous recent disaster declarations and the availability of post-disaster mitigation funds have provided further incentive to complete local plans.

Since local plans are required to be updated every five years, SEMA focused resources on updating plans as they were expiring. In addition, guidance documents were created, one-on-one technical assistance and training sessionis were offered both in conjunction with FEMA or individually. Sessions were also offered with communities when new maps were issued. FEMA released the *Local Multi-Hazard Mitigation Planning Guidance*, in July 2008 that also assisted local planning efforts. To facilitate the update process, SEMA worked with the RPCs by providing updated FEMA guidance, new county-level Hazus risk assessment results for earthquakes and floods, and by hosting planning workshops. SEMA also provided additional planning assistance through the services of a new full time mitigation planner

specializing in local mitigation plans. FEMA has released a planning guidance in 2011 and became effective in October 2012. In addition, FEMA released a new mitigation handbook in March 2013.

With the five-year update requirement for local plans, many updates are due in 2010 and 2011. SEMA continued coordinating with RPCs on the local update process that began in 2008, using additional staff hired for the purpose of coordinating local plans, to ensure that the local plan updates are fully supported by SEMA staff. Support for the update process will continue indefinitely to ensure that plans expiring in 2012, 2013, 2014, and beyond are fully supported and updated.

SEMA also continues to encourage local governments without mitigation plans to apply for PDM planning grants. SEMA encourages participation in multi-jurisdictional plans and is considering how to handle jurisdictions that chose not to participate in their county- level plans but are now interested in developing individual plans.

5.1.4 Funding

There are two primary sources of funds available to help local jurisdictions develop and update hazard mitigation plans. These sources are FEMA's HMGP and PDM planning grants. Detailed information about these programs is available in Section 4.5 Funding Sources.

Hazard Mitigation Grant Program

Planning Applicability
Up to 7 percent of the HMGP funds set aside following a Presidential Disaster Declaration may be used to develop FEMA-approved mitigation plans.
SEMA Fund Administrator
Logistics, Resources, Mitigation and Floodplain Management Branch, State Hazard Mitigation Officer

Missouri Local Hazard Mitigation Grant Program Planning Distributions
Table 5.1.4a shows the HMGP funds used to fund the local mitigation planning from Presidential disasters in 2002 - 2008. There were no HMGP funds available for local planning in 2004, 2005, 2010 or 2011.

Table 5.1.4a HMGP funds used for Local Planning 2002-2012

Year of Federal Declaration	Declaration Number	Federal 75% share
2002	DR 1403	$529,366
2002	DR 1412	$135,600
2003	DR 1463	$139,689
2006	DR 1635	$294,736
2007	DR 1676	$750,000
2007	DR 1708	$81,758
2007	DR 1736	$235,620
2008	DR 1749	$150,000

Year of Federal Declaration	Declaration Number	Federal 75% share
2009	DR 1809	$153,972
2009	DR 1822	$334,454
2012	DR 1847	$299,997
Total		**$3,076,322**

Source: State Emergency Management Agency

It is anticipated that additional funds from presidential disaster declarations DR 1809, DR 1822, and DR 1847, which occurred in 2008-2009, may also be used in the development of local mitigation plans, but the funding levels have not yet been determined.

Pre-Disaster Mitigation Program

Planning Applicability

PDM grants can be used for mitigation plan development, upgrades, comprehensive reviews and updates. Recipients of PDM planning grants must produce FEMA-approved hazard mitigation plans.

SEMA Fund Administrator

Logistics, Resources, Mitigation and Floodplain Management Branch, State Hazard Mitigation Officer

Missouri Local Pre-Disaster Mitigation Program Planning Distributions

PDM grants are also used for the development of local mitigation plans. In Table 5.1.4b below, it shows that over $1.2 million in federal PDM funds have been used from 2002 through 2005 in Missouri. PDM funds from 2006-2012 have not been used for local planning but for projects instead.

Table 5.1.4b PDM funds used for Local Planning 2002-2012

Year of PDM Funding	Federal 75% share
2002	$367,466
2003	$248,375
2005	$627,580*
Total	**$1,243,421**

Note: * The 2005 funds included State and Local Planning
Source: State Emergency Management Agency

5.1.5 Technical Support

SEMA provides technical planning support to local jurisdictions through the Mitigation Section of the Logistics, Resources, Mitigation and Floodplain Management Branch. As discussed in Section 5.1.3 Process to Provide Local Assistance, SEMA contracted with the RPCs and provided them with guidance written by the state hazard mitigation officer to develop mitigation plans for the local governments in their regions. As discussed in Section 5.1.3, SEMA provided new FEMA guidance and held workshops to facilitate the five-year updates for local plans.

SEMA continues to provide support to the RPCs, as well as directly to local governments, for new and updated plans. SEMA's Mitigation Section has the ability to offer FEMA G-318, Mitigation Planning Workshop for Local Governments. This course is an in-person, 2-day workshop covering the fundamentals of mitigation planning requirements for communities to develop new or updated Local Mitigation Plans that address community priorities and needs and meet requirements established in 44 CFR 201.6. This workshop describes the planning process, the requirements for stakeholder involvement, assessing risks and developing effective mitigation strategies. In addition, SEMA's Mitigation Section provides program specific information related to federal/state mitigation policy, state mitigation priorities, program administration, funding sources, and project eligibility requirements. FEMA G-318 was last presented in May of 2010. In addition to the mitigation planning workshop, SEMA has offered a course in mitigation application orientation and BCA (Benefit Cost Analysis) training in 2010 and 2011. FEMA G-393, Mitigation for Emergency Managers, was offered three times in 2012.

Also, since November 2007, full time support is available through a Mitigation Planner working full time with local mitigation plan projects. This Mitigation Planner is available for specific hands-on instruction, to attend local community planning meetings if requested, and review the local plan documents in all stages of development. This Mitigation Planner also uses the bulletin board on the Missouri Association of Councils of Government's website, http://macog.proboards.com/index.cgi to post messages. The bulletin board contains information on the local hazard mitigation planning process.

With this Mitigation Planner, the overall effectiveness of the local plans has increased. The Mitigation Planner is able to give the local RPC planners ideas for specific hazards data, sample vulnerability analysis based on available data for their area, thus creating a more detailed local multi-hazard mitigation plan particularly for more vulnerable jurisdictions (i.e. highly populated communities).

Instructional methodology is offered through the update and revision of the State Hazard Mitigation Plan. This 2013 state plan update includes a vulnerability analysis for all 21 hazards. If a local community does not have a methodology to use for their local hazard vulnerability, then the state plan methodology is an option for them to use.

More specific details will be available in the near future for local planners concerning dams and levees. DNR is in the process of coordinating the development of inundation maps for all High Hazard Potential Dams in Missouri. This initiative started in late 2009. As of May 2013, the inundation mapping is roughly 80% complete. The DNR anticipates a spring 2014 completion of the inundation mapping, and dam owner workshops. Also, the U.S. Army Corps of Engineers has developed an online levee inventory system that SEMA has access to. This inventory provides details on levees currently in the USACE Levee Safety Program and to describe their levee protected areas. Future plans for this inventory include adding for informational purposes levees not in the USACE Levee Safety Program. It is proposed that this data be made available local governments. This type of local-level access would prove very useful in providing needed data to complete vulnerability assessments and develop mitigation strategies to address levee failure hazards in their local mitigation plans.

This attached link provides a HAZUS instructional methodology that can be used in local plans in determining the number of structures and populations in dam and levee inundation/protected areas that may be at risk if a dam or levee is compromised by failure or overtopping.

This 2013 state plan update includes county level maps of the 100-year floodplain to be used in local flood risk assessments which help locals assess/reassess their potential flood risk. The maps use

integrated DFIRM derived depth grids for 80 jurisdictions (79 Counties and the City of St. Louis) and the remaining 35 jurisdictions use Hazus 2.1 generated floodplains. All maps are also available by contacting SEMA's Mitigation Section.

5.2 Local Plan Integration

Requirement §201.4(c)(4)(ii):	[The section on the coordination of local mitigation planning must include a] description of the State process and timeframe by which the local plans will be reviewed, coordinated, and linked to the state mitigation plan.
Update §201.4(d):	Plan must be reviewed and revised to reflect changes in development, progress in statewide mitigation efforts, and changes in priorities.

5.2.1 Review and Approval of Local Plans

The DMA 2000 (Section 322(b)) calls for each local plan to "describe actions to mitigate hazards, risks, and vulnerabilities identified under the plan and establish a strategy to implement those actions." FEMA expanded on these basic criteria and established specific requirements for local mitigation plans in *Local Multi-Hazard Mitigation Planning Guidance*, July 2008. SEMA's hazard mitigation plan guidance dictates that local hazard mitigation plans be developed to meet all federal requirements, address the specific hazard mitigation needs of the applicable jurisdictions, and complement the Missouri State Hazard Mitigation Plan. The state plan is used as a reference for locals to refer to in plan development. To ensure that local hazard mitigation plans meet these established criteria, SEMA works closely with the RPCs and local jurisdictions.

Local hazard mitigation plans undergo a continuous review during development that involves state and local officials and concerned members of the applicable communities. This helps to ensure that plans develop smoothly and that the final plan is acceptable to the jurisdiction, its citizens, and the State. In 2004, SEMA reviewed all of the local plans before sending them on to FEMA. In 2007, SEMA began contracting the reviews out to one of the RPCs in order to assist in reviewing the large number of plans generated. At that time SEMA's process for local plan review and approval was as follows:

- SEMA contracts with the reviewing RPC to review the plan
- The submitting RPC submits the plan to SEMA
- SEMA sends the plan to the reviewing RPC
- The reviewing RPC works with the submitting RPC to resolve any concerns, as necessary
- Prior to adoption, the submitting RPC submits a revised draft to SEMA
- SEMA sends the draft to FEMA Region VII for conditional approval
- FEMA notifies SEMA of conditional approval
- SEMA notifies the submitting RPC of conditional approval
- The jurisdictions adopt the plan
- The submitting RPC sends the adopted plan with the resolutions to SEMA

- SEMA sends an electronic copy of the adopted plan with the resolutions to FEMA Region VII
- FEMA grants final approval (this determines the date of approval)
- SEMA notifies the submitting RPC of final approval with a letter

This process changed significantly in November 2007 with the addition of a full time mitigation planner at SEMA that specializes in local mitigation planning. Rather than submitting plans to another RPC for review, plan reviews are now completed by the full time mitigation planner. These reviews are completed as quickly as possible in order to provide for sufficient time to complete any necessary revisions prior to submission to FEMA.

The current process used to review and approve both new and updated plans is outlined below:

- The submitting RPC submits the plan to SEMA
- The SEMA mitigation planner works with the submitting jurisdiction or RPC to resolve any concerns as necessary and completes a formal review of the plan
- After successful integration of the required plan elements the plan is approved by SEMA
- A finalized version of the plan is submitted to SEMA prior to adoption
- SEMA sends the Draft to FEMA Region VII for conditional approval
- FEMA notifies SEMA of Approval Pending Adoption
- SEMA notifies the submitting jurisdiction or RPC of conditional approval
- The participating jurisdictions adopt the plan
- The submitting jurisdiction or RPC sends the adopted plan with resolutions to SEMA
- SEMA sends and electronic copy of the adopted plan with resolutions to FEMA Region VII
- FEMA grants final approval (this determines the date of approval)
- SEMA notifies the submitting jurisdiction or RPC of final approval with a letter

SEMA’s goal is to complete local plan reviews within three weeks from the date of final plan receipt. During times of peak demand for review, plans are prioritized based on date of expiration for review in order to ensure that the expiration of plans is avoided. Challenges facing plan developers were numerous since the last plan update as disasters (DR-4130, 4012, 1980 & 1961) that impacted the state, the tightening of budgets, and new resources were delayed, resulted in more draws on time.

Local mitigation projects and initiatives are based on the goals and objectives of local plans. However, it is understood that funding, situations, and priorities change. SEMA and FEMA allow jurisdictions the flexibility to add/subtract mitigation projects as priorities, due to funding and other changing circumstances. Changes may be made to the plan review process, if needed, to comply with FEMA’s guidance for local plan updates.

5.2.2 Integrating the Local Plans with the State Plan

The process of integrating state and local mitigation planning began with state staff involvement and guidance in the local planning process. It is understood by all levels of government that the success of the Missouri mitigation program depends on the degree to which everyone works together toward the common goal of reducing future disasters in Missouri. This is accomplished by involving as many interested groups and individuals as possible in the planning process. State mitigation staff meet with the RPCs and jurisdictions as needed throughout the planning process. While there is no specific schedule for these meetings, they occur:

- During scheduled public meetings
- At the start of the planning process
- At the mid-point of plan completion
- At plan completion
- As requested by the RPC and/or affected jurisdiction

It is also widely acknowledged that the local plans can benefit from data in the state plan, and the state plan can benefit from data in local plans. For this 2010 plan update, the SHMPT reviewed and summarized information from the local plans. This information included:

- Hazard identification and risk assessment
- Goals and objectives
- Local capabilities
- Mitigation initiatives

The process in 2013 involved reviewing all of the local community plans and capturing the information related to the four categories above in spreadsheets for further review and comparison purposes. (For more details on this process, and how the information was collected and incorporated, see Section 3.6 Assessing Vulnerability and Estimating Losses by Jurisdiction: Integration of Local Plans, Section 4.1 Hazard Mitigation Goals and Objectives, Section 4.3 Local Capability Assessment, and Section 4.4 Mitigation Actions.) This information was used to reassess state hazard and capabilities priorities and the progress in statewide mitigation efforts. Specifically, SEMA is interested in:

- Adding initiatives that proved successful at the local level
- Researching development of mitigation initiatives that address local concerns
- Reviewing state initiatives to determine if they are meeting the overall mitigation needs of the State
- Changing or eliminating mitigation initiatives that have not produced anticipated results

- Over the past three years, SEMA has been well defined, actionable items that tie to the overall mitigation strategy. Additionally SEMA has conducted, or is in the process of conducting a series of resilience meetings where information on tracking and coordinating NFIP/RiskMAP/Mitigation actions is being provided to local communities.

As of May 2013, this state plan update is integrated with existing and updated information from 113* local hazard mitigation plans. These include 33 expired plans, six first plans in progress, and two counties with no hazard mitigation plan. Therefore there are 41 communities without an active, or FEMA approved hazard mitigation plan. Based on the 115 counties (including St. Louis City) in the state, approximately 64% of the counties have an active plan in effect. These 113 plans cover 99.15% of Missouri's population. New and updated plans will continue to be incorporated into the state plan during the next three-year update cycle due in 2016.

Note: 113* includes 112 local county plans, plus the City of St. Louis, that have been FEMA approved, updated, and/or expired.

5.2.3 Successes and Challenges in Integration

This 2013 update reflects the successful integration of 75 updated local hazard mitigation plans. Since Missouri has 114 counties plus the independent City of St. Louis City and 948 incorporated cities, towns,

and villages, SEMA was challenged with how to effectively and efficiently develop plans for each of these jurisdictions. SEMA streamlined the process by encouraging local governments to participate in multi-jurisdictional county-level plans, which reduced the number of plans that needed to be reviewed and integrated into the state plan and brings communities together to focus on mitigation. For example, flood problems don't stop at corporate boundaries and coordinated planning is necessary to tackle those issues.

Another challenge of integration of the county-level plans, is that because of hazard mitigation assistance grant funding availability, the plans are cycled to expire in different years so not all the county-level plans can be integrated at one time.

SEMA had hoped to further streamline the integration of local plan data into the state plan by providing guidance through the full-time mitigation planner. While it did prove to be successful, local risk assessments used different methods and interpretations to determine vulnerability and used different measures to assess risk. In addition, the local's definition of 'severity' seems to conflict with the State's, as locals term it as extent while to the State this refers to vulnerability. Therefore, it was a challenge to compare the counties to see where one might be more vulnerable to a particular hazard than another. Challenges to be addressed by SEMA going forward include trying to resolve these inconsistencies with the local plans. (More information about local plan integration can be found in Section 3.6 Assessing Vulnerability and Estimating Potential Losses by Jurisdiction: Integration of Local Plans, Section 4.1 Hazard Mitigation Goals and Objectives, Section 4.3 Local Capability Assessment, and Section 4.4 Mitigation Actions.) The State, as mentioned in Section 5.1.5 Technical Support, is providing Hazus developed county level maps of the 100-year floodplain in the 2013 update state plan update to be used in local flood risk assessments which will help locals assess/reassess their potential flood risk.

SEMA will consider FEMA's comment pertaining to moving some of the impact sub-section information from the Hazard Profile Sections into the Vulnerability sections as part of the next plan update process. This will help to clarify many of the terms that can lead to confusion at the local level. For the purposes of this plan, the term severity is intended to be a measure of extent, as it is defined on page 3.21. SEMA believes that this clarification will help local planners to begin standardizing this term that may currently lead to confusion.

5.3 Prioritizing Local Assistance

Requirement §201.4(c)(4)(iii):	[The section on the coordination of local mitigation planning must include] criteria for prioritizing communities and local jurisdictions that would receive planning and project grants under available funding programs which should include: • Consideration for communities with the highest risks, • Repetitive loss properties, and • Most intense development pressures. Further that for non-planning grants, a principal criterion for prioritizing grants shall be the extent to which benefits are maximized according to a cost benefit review of proposed projects and their associated costs.
Update §201.4(d):	Plan must be reviewed and revised to reflect changes in development, progress in statewide mitigation efforts, and changes in priorities.

This section describes the criteria Missouri uses to prioritize distribution of planning and project grants to communities and local jurisdictions. The criteria and process remain the same as was indicated in the 2004, 2007 and 2010 plans. SEMA is constantly striving to improve the number of practical and fundable mitigation projects that are identified in local plans and funded by the State. As such, a set of prioritization criteria will be developed for the next revision of the plan, in order to further upgrade the mitigation strategies that are contained in approved plans. SEMA will also provide additional information to communities such as Hazus and Risk MAP data, and provide training to encourage the development of actionable mitigation strategies.

5.3.1 Planning Grants

Federal and state funding for mitigation planning is limited and in some instances not available. The Flood Mitigation Assistance Program, Hazard Mitigation Grant Program, and Pre-Disaster Mitigation program are the primary sources of funding for mitigation planning. In the past, funding to meet the nonfederal match requirement of these grants came from Missouri’s general revenue and local sources (cash and in-kind). Future non-federal matches will need to come primarily from local sources; as state general revenue will no longer be available.

There are always more requests for financial assistance for mitigation planning funds than there are funds available. Funding for mitigation planning is based primarily on the availability of funds and whether the requesting jurisdiction has demonstrated the desire and ability to complete their plan as well as to follow through with the initiatives developed in the plan (which should not be dependent on the availability of state or federal funds). The expiration date of any current plan is also taken into consideration when evaluating the possibility of a plan update project.

As a result of two presidentially declared disasters in 2002 (DR 1403 and DR 1412) and one in 2003 (DR 1463), SEMA had a limited amount of planning funds available. The decision was made to use these funds to help meet the local hazard mitigation planning requirement. Since these funds were not

sufficient to develop all of the required plans, SEMA developed criteria to select counties for funding in every region of the State: relationship to major rivers, population, number of federal disaster declarations (past 25 years), participation in the National Flood Insurance Program, and past mitigation funding.

Over time, SEMA developed a more sophisticated method of prioritizing funding. SEMA now uses the following list of questions to help guide the distribution of mitigation planning funds. These criteria evolved as funding levels and expiration dates shifted over time. The most effective strategies included the integration of community planning capacity, staggering of plans with Regional Planning Commissions in order to prevent overload, and providing funds directly communities instead of RPCs where appropriate.

- Does the community meet the criteria for the applicable grant program (FMA, HMGP, PDM)
- Based on the State and local risk assessment, what is the susceptibility of the community to natural and manmade disasters
- Based on presidential disaster declarations, how many times has the community experienced disasters and what was the resulting damage (community infrastructure as well as families and businesses)
- How many disasters that did not receive presidential declarations affected the community and what was the resulting damage (community infrastructure as well as families and businesses)
- Does the community participate in the National Flood Insurance Program? If so, how many insured, repetitive loss structures are in the community
- Is the community a small and impoverished community or does it have special developmental pressures
- Based on previous grant experiences (such as disaster grants, mitigation projects, other grants, etc.) what is the community's record of successful performance
- Based on previous grant experiences with other state agencies (e.g., the Department of Economic Development Community Development Block Grant program) and the community's Regional Planning Commission/Council of Government, what is the community's record of successful performance
- Has the community demonstrated the ability to form effective public-private hazard mitigation partnerships
- Does the Community have a current plan which may expire without additional funding support

5.3.2 Project Grants

Federal and state funding for mitigation projects is also limited due to budget constraints for the past three years, the State has to prioritize proposed local mitigation projects. The Flood Mitigation Assistance Program, Hazard Mitigation Grant Program, and Pre-Disaster Mitigation program are the primary sources of funding for mitigation projects. The State intends to increase the utilization of the Repetitive Loss Flood Claims and Severe Repetitive Loss programs for repetitive-loss mitigation. Funding to meet the non-federal match requirement of these grants comes mostly from U.S. Department of Housing and Urban Development (HUD) Community Development Block Grants (CDBG) and Missouri's general revenue. As state general revenue is no longer available, future matching funds will have to come primarily from local sources. Ideally, all communities will participate in some form of mitigation; however, due to differences in local capabilities and priorities, including the status of local mitigation plans, the degree of participation varies greatly from community to community.

In evaluating mitigation projects that have been submitted for review and possible approval, SEMA considers several factors, which include, but are not limited to, the following:

- The specific requirements and/or restrictions placed on the projects by the funding source
- There will always be more requests for mitigation funds than there will be available funds
- Federal and state funding for mitigation projects will be limited and in some instances may not be available
- Whenever possible, local jurisdictions should develop mitigation projects and initiatives that can be funded locally
- Local jurisdictions should actively pursue public-private partnerships, where appropriate, to achieve desired mitigation goals
- The requested mitigation project should complement the goals and objectives of the State and local mitigation strategy

When determining which communities will receive project grants, SEMA considers the basic criteria for assistance awards established by the Disaster Mitigation Act of 2000 (Section 203(g)):

- The extent and nature of the hazards to be mitigated
- The degree of commitment of the local government to reduce damages from future natural disasters
- The degree of commitment of the local government to support the hazard mitigation measures to be carried out using the technical and financial assistance
- The extent to which the hazard mitigation measures to be carried out using the technical and financial assistance contribute to established state/local mitigation goals and priorities
- The extent to which prioritized, cost-effective mitigation activities that produce meaningful and definable outcomes are clearly identified
- The extent to which the activities above are consistent with the local mitigation plan
- The opportunity to fund activities that maximize net benefits to society
- The extent to which assistance will fund activities in small and impoverished communities

Missouri's highest project priorities consider hazards, vulnerability, capabilities. Flood buyout projects (especially for repetitive and severe repetitive loss properties), and other flood mitigation and structural projects to protect essential infrastructure are the first priority. Projects to protect individuals from tornadoes and high wind rank second, followed by projects to reduce losses from earthquakes.

Specifically, SEMA uses the following list of questions to help guide the distribution of mitigation project funds:

- What is the hazard to be mitigated
- Does the applicant have a FEMA-approved mitigation plan
- Does the project complement state and local mitigation goals and objectives identified in the mitigation plans
- Is the hazard being mitigated a priority hazard in the applicant's mitigation plan
- Is the project cost-effective based on FEMA's benefit-cost analysis module
- Does the project have the potential to substantially reduce the risk of future damage, hardship, loss, or suffering that may result from a major disaster

- Does the project result in mitigating flood damage to repetitive loss or severe repetitive loss properties
- In the past, what mitigation efforts were undertaken by the applicant using local funds and initiatives and what were the outcomes
- What is the applicant's disaster history
- Are sufficient mitigation funds available to complete the project
- Does the applicant have sufficient funds (if other funds are not available) to meet the local share of the project
- Does the applicant have the capabilities to complete the project as submitted
- Does the project independently solve a problem
- Does the project have the potential to have a larger impact on the local and state mitigation program than other submitted projects
- Does the project have any negative impacts on neighboring communities

When funding comes from the HMGP (post-disaster funding), priority is given to mitigation projects related to the hazard that necessitated the disaster declaration and those jurisdictions included in the disaster declaration.

Additional information about the process SEMA uses to evaluate and prioritize mitigation actions and determine cost-effectiveness is available in Section 7.2.1 Process Used to Evaluate and Prioritize Mitigation Actions, Section 7.2.2 Eligibility Criteria for Multi-hazard Mitigation Projects, Section 7.2.3 Eligibility Criteria by Mitigation Project Type, and Section 7.2.4 Pre-Project Determination of Cost-Effectiveness of Mitigation Measures.

5.3.3 Small and Impoverished Communities

44 CFR 201.2 establishes the following definition for small and impoverished communities:

"Small and impoverished communities means a community of 3,000 or fewer individuals that is identified by the State as a rural community, and is not a remote area within the corporate boundaries of a larger city; is economically disadvantaged, by having an average per capita annual income of residents not exceeding 80 percent of national, per capita income, based on best available data; the local unemployment rate exceeds by one percentage point or more, the most recently reported, average yearly national unemployment rate; and any other factors identified in the state plan in which the community is located."

Hazard Mitigation Grant Program
In regard to the plan requirement for HMGP project funds, the FEMA regional administrators may waive this requirement for small and impoverished communities. In these cases, a plan must be completed within 12 months of the award of the project grant. This process is to be used judiciously and should not be viewed as the normal sequence of the planning process.

Pre-Disaster Mitigation Grant Program
Small and impoverished communities that receive grants from the PDM program may receive a federal cost share of up to 90 percent of the total amount approved under the grant award (as opposed to the typical 75 percent federal cost share). Documentation must be submitted with the sub-application to support the eligibility for the higher cost share.

***Technical Note**: This document is a User Interfaced, Web Based Interactive Document. It has been formatted with active embedded hyperlinks throughout. There are several different types of hyperlinks.*
Hyperlinks within the document: Some of the hyperlinks will direct the user to specific sections of the plan where referenced information may be found. These links are identified by a blue color format.
Hyperlinks to SEMA website: Some of the hyperlinks will direct the user to a SEMA website to access reference documents and resource data. Some of these documents are password protected and the user will be directed to obtain credentials from SEMA to gain access. These links are identified by a red color format.
Hyperlinks to external websites: These hyperlinks will direct the user to a third party website where additional information can be found. As with all hyperlinks to external sites, if the site administrator makes changes to the URL, these can expire or become non-functional. These links are identified by a green color format.
This chapter focuses on two aspects of the State's involvement in the plan maintenance process:

Also included in this chapter is a description of state agency responsibilities and staffing duties as they relate to the plan maintenance process, including the process for monitoring progress of mitigation activities.

6.1 Monitoring, Evaluating, and Updating the Plan

Requirement §201.4(c)(5)(i):	[The standard state plan maintenance process must include an] established method and schedule for monitoring, evaluating, and updating the plan.

As described in detail in Chapter 2, this update to the Missouri State Hazard Mitigation Plan is the result of the combined efforts of members of the State Risk Management Team (SRMT) which is composed of state, federal, local, and voluntary agency representatives. For a detailed listing of agencies represented on the SRMT, see Section 2.1.2.

Hazard mitigation planning is a continuous and ongoing process. Policies and procedures established in this plan reflect the current emergency management and hazard mitigation philosophy at both the state and national level. Changes in hazard mitigation programs and/or priorities, including changes in legislation and available funding, may necessitate modifications to this plan. A major disaster could also prompt modifications to this plan.

6.1.1 Plan Maintenance Process

The Mitigation Section of the Logistics, Resources, Mitigation, and Floodplain Management Branch within SEMA is the lead group responsible for developing, monitoring, and updating the State Hazard Mitigation Plan. Meetings of the SRMT are scheduled by the Mitigation Section as needed to review and update this plan. Moving forward, these meetings are to be conducted at a minimum:

- In the event of a major disaster and/or upon receiving a Presidential Disaster Declaration, if needed/warranted;
- As part of the State's hazard mitigation plan review/update every three years or as required; and
- When required/needed due to changes in federal/state regulations and/or legislation that impact the hazard mitigation program.

In addition to the update requirements mentioned above, annually SEMA conducts an in-house review and update in order to assess the plan on a more regular basis. This review, done in conjunction with the development of SEMA's annual hazard analysis, continues to allow the State to direct its priorities in the appropriate manner before disasters occur.

The following SEMA branches and other state agencies and departments participate in the development, review, and update of the state plan:

- SEMA's Logistics, Resources, Mitigation, and Floodplain Management Branch;
- SEMA's Planning and Disaster Recovery Branch;
- Members of the SRMT; and
- Other SEMA branches and/or state agencies and departments that may be asked to assist in the review of this plan based on legislative changes, FEMA policy changes, or State priorities affecting the state hazard mitigation program.

Representatives from the various agencies and departments on the SRMT are responsible for reviewing the plan, providing input and suggesting changes to the plan based on the mitigation initiatives being undertaken by their respective organizations.

During updates, state agencies:

- Review the risk assessment and revise if necessary;
- Review the vulnerability assessment and loss estimates and revise if necessary;
- Review goals and objectives and revise if necessary;
- Review hazard mitigation projects and initiatives to ensure there are no potential conflicts with ongoing agency initiatives;
- Review hazard mitigation projects and initiatives to ensure they complement the statewide mitigation strategy; and
- Review existing state/federal programs to ensure that the state is taking full advantage of possible funding sources in its implementation of the State hazard mitigation program.

A review of plan goals and objectives is emphasized as part of the regular plan review process. The review is in conjunction with the review and approval process of local hazard mitigation plans. This helps to ensure that the state and local hazard mitigation plans complement each other and that both state and local governments are working together to accomplish Missouri's mitigation goals. Additionally, proposed mitigation projects are reviewed to determine how they help state and local governments meet their established goals and objectives.

Plan maintenance implies an ongoing effort to monitor and evaluate plan implementation and to update the plan as progress, roadblocks, or changing circumstances are recognized. Evaluation of progress can further be achieved by monitoring changes in vulnerabilities identified in the plan.

Public involvement in the hazard mitigation process is accomplished through open public meetings as part of the development and review of local hazard mitigation plans. This process began when the Regional Planning Commissions got involved with local mitigation planning meetings in 2004 and continues as local mitigation plans are developed and updated. State and local representatives participate in these meetings and public input is sought and taken into consideration in developing mitigation priorities.

2013 Plan Update

For this update to the Missouri State Hazard Mitigation Plan, the previously approved plan maintenance process was followed and evaluated. The SRMT determined that the elements and processes originally proposed to monitor, evaluate, and update the plan were effective. With 4 Presidential Disaster Declarations in a 3-year period since the 2010 Mitigation Plan Update, the State capitalized on post-disaster coordination activities with other state and federal agencies to incorporate monitoring and evaluation activities for the Hazard Mitigation Plan.

It should be noted that the SEMA Mitigation Section is the lead group responsible for developing, monitoring, and updating the State Hazard Mitigation Plan. As such, the following meetings will be conducted by SEMA, at a minimum, as part of the ongoing Plan Maintenance Process:

- In the event of a major disaster and/or upon receiving a Presidential Disaster Declaration
- As part of the State's hazard mitigation plan review and update every three years, or as required
- When required or needed due to changes in federal or state regulations and/or legislation that impacts the State's hazard mitigation program

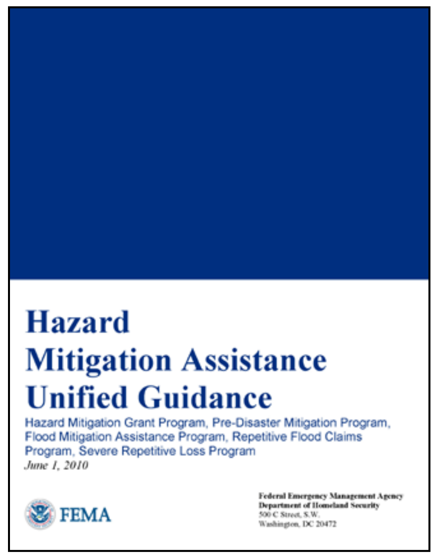
As part of the disaster declaration process the State Emergency Operations Center was activated with each declaration. The members of the SRMT that participated in the response and recovery of those disasters came together to discuss implementation of the mitigation strategy as additional post-disaster mitigation funds became available. The State Hazard Mitigation Officer (SHMO) chairs the Voluntary Buyout and Relocation Subcommittee which was merged with the Housing and Business Assistance Subcommittee and meet at the same time. The members of this subcommittee include representatives from SEMA (Mitigation, Floodplain Management, and Public Assistance); Dept of Economic Development (Community Development Block Grant), MoVOAD, Mo Dept of Natural Resources Air Quality along with the State Historic Preservation Office; Missouri Housing Development Commission; Missouri Division of Finance; Missouri Public Service Commission; Missouri Dept of Conservation; FEMA; HUD; SBA; U.S. Army Corps of Engineers; and U.S. Department of Agriculture Rural Development.

6.2 Monitoring Progress of Mitigation Activities

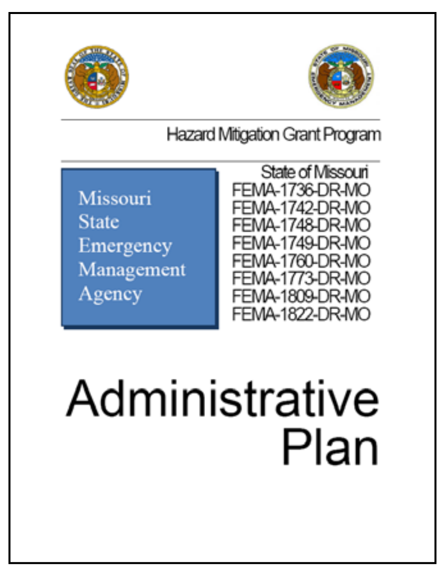
Requirement §201.4(c)(5)(ii) and (iii):	[The standard state plan maintenance process must include a] system for monitoring implementation of mitigation measures and project closeouts. [The standard state plan maintenance process must include a] system for reviewing progress on achieving goals as well as activities and projects in the mitigation strategy.

6.2.1 Monitoring Implementation of Mitigation Measures and Project Closeouts

The State of Missouri ensures all Hazard Mitigation Assistance (HMA) grants are implemented in accordance with current FEMA guidance. The most current FEMA guidance is the September 26th, 2012 FY 2011 *Hazard Mitigation Assistance (HMA) Unified Guidance:* *Hazard Mitigation Grant Program, Pre-Disaster Mitigation Program, Flood Mitigation Assistance Program, Repetitive Flood Claims Program, Severe Repetitive Loss Program*. The State has established a monitoring system for tracking the implementation and closeout of mitigation actions. With this 2013 plan update, the State is developing a web-based system and coordinated strategy to track and measure the effectiveness of mitigation actions. This effort is discussed in more detail in Section 7. This system will link existing tracking systems to allow for one integrated system to track mitigation grants and their effectiveness.



The most current Administrative Plan, approved by FEMA in December 31, 2010, provides details on how the State monitors implementation of mitigation measures and conducts project closeouts for the Hazard Mitigation Grant Program (HMGP). Although not all Hazard Mitigation Assistance Grants require a detailed State Administrative Plan, the State applies the basic monitoring and closeout procedures set out in the HMGP Administrative Plan consistently in the other applicable HMA programs where the State serves as grantee. This section includes a description of the current state monitoring system and modifications to the system identified during the 2013 plan update.



Mitigation Measures Monitoring System

The following paragraphs detail how the State tracks the implementation of mitigation actions and project closeouts.

Project Management

Upon notification from FEMA that a project has been approved and is eligible for funding, the SHMO will notify the subgrantee and will arrange a meeting to provide the subgrantee with appropriate information on regulatory program requirements, State policy and grant management in accordance with 44 CFR 13. Materials provided to the subgrantee, dependent on the type of project, may include:

- For tornado safe room projects, a *Hazard Mitigation Community Safe Room Project Administration Guidebook.* It will provide the policy and procedures specific to the type of project. For all other projects, guidebooks will be provided that are specific to the project.
- For buyout projects, *A Local Officials Guide to Managing a Voluntary Buyout*. It will provide the policy and procedures specific to the type of project.
- 44 CFR Parts 13 and 14.
- OMB Circulars A-87 (as relocated to 2 CFR, Part 225), A-122 (as relocated to 2 CFR Part 230), A-133, and/or other applicable circulars.
- Example procurement, financial, etc. documentation.

The State Emergency Management Agency is the grantee for project management and accountability of funds in accordance with 44 CFR 13. Approved applicants are considered subgrantees and are accountable to the grantee for funds awarded them.

Technical Assistance and Project Monitoring

SEMA (as grantee) recognizes their regulatory responsibilities for all HMA grants: The State, serving as grantee, has primary responsibility for project management and accountability of funds as indicated in 44 CFR 13. The State is responsible for ensuring that subgrantees meet all program and administrative requirements.

SEMA is committed to monitoring and providing technical assistance to all eligible and funded subgrantees. The SHMO, project manager, and/or technical support staff attend subgrantee meetings to ensure the policies and procedures are explained correctly. Numerous worksheets, financial forms, and targeted guidebooks for local officials (e.g., the Mitigation Planning Workshop for Local Governments and the All-Hazard Mitigation Planning Guidebook for Communities) have been developed by SEMA and have proven successful. SEMA also directs local governments to locate FEMA's "How-To" Guidebooks for mitigation Planning.

To track mitigation projects from initiation to closeout, a project tracking spreadsheet is used that includes the following information:

- Subgrantee name
- Project name
- Grant amount
- Percent expended
- Percent completed
- Grant end date
- Completion description (by project task and percent complete)

A system to track each individual grant process completion has been developed and is tied to steps associated with specific project types. Table 6.2.1a shows an example for a buyout project and how a percent is tied to a specific action completed.

Table 6.2.1a Project Tracking System—Buyout Example

Buyout	Percent Complete of the Project Process
Buyout Policy	10%
Voluntary Agreements	20%
Appraisals Contracted	30%
Appraisals Completed	40%
Title Search Completed	50%
Properties Closed	60%
Asbestos Determination	70%
Demolition Contracted	80%
Demolition Completed	90%
Final Invoices Paid	100%

When necessary, a SEMA Mitigation Staff Member member attends the first closing of a buyout project to offer assistance in completing the necessary FEMA forms (e.g., Voluntary/ Uniform Relocation Act, Duplication of Benefits, Closing Statement).

Site visits, telephone conversations, e-mails, and facsimiles remain the best communication tools for the buyout program and any other mitigation project. Past mitigation successes reflect this; thus, SEMA is confident these mechanisms ensure subgrantees success in administering the HMA grants within federal and state regulations and policies. SEMA requires monthly progress reports (instead of quarterly) from subgrantees so that issues with implementation can be identified and handled in a timely manner.
A modified Standard Form 270, Request for Advance or Reimbursement, is used by SEMA for processing fund requests. General principles for processing Request for Funds (RFF) forms are as follows:

1) Verify RFF is original (no facsimiles) and signed by authorized signor;
2) Verify spreadsheet "program allocated" and "administration allocated" columns are correct for the subgrantee;
3) Verify the "current draw" columns are correct;
4) Check for mathematical accuracy on the RFF;
5) Check for supporting documentation (property list, invoices, equipment and materials costs, etc.);
6) Verify all properties requested to be funded have Duplication of Benefits released and State Historic Preservation Office clearance;
7) Enter amounts requested on spreadsheet;
8) Forward to Financial Department for processing; and

9) Copy all documents to project file.

As a general rule, a portion of project funds are withheld until project closeout. Planning projects will be paid in phases of project completion, with a percentage withheld pending FEMA's approval of the mitigation plan. For construction projects, only 95 percent of the total project funds will be reimbursed prior to completion of the construction.

Cost Overruns

Immediately upon recognition that an original scope of work approved and funded cannot be accomplished with the grant funds allocated, the subgrantee must submit a request for additional funds with appropriate justification. Upon receipt, the State will review the documents and make a determination. If the request is justifiable, the State will perform a revised benefit-cost analysis (BCA). If the BCA results in a 1.0 or above and funding is still available, the State will forward the request with its recommendation to the FEMA Regional Administrator. If the request is not justifiable the State will deny the request. In no case will the total amount obligated to the State exceed the specific HMA program funding limits.

For purposes of the mitigation buyout program, cost overruns are defined to be additional funds necessary to complete the acquisition of the target area defined in the original application submitted to FEMA for funding. Cost estimates for individual structure/lots on applications can be somewhat volatile. Property closings resulting in an overrun based on the estimate that can be offset by property closings resulting in a net under-run are not considered cost overruns for this purpose and thus do not need FEMA approval.

Any properties "added" to the property list after initial submission to FEMA would be considered a change in scope and will require SEMA and FEMA approval. No changes can be made to the property list after the application period has passed and the application has been approved by FEMA. In addition, adjustments to budget line items based on the Buyout Application do not need FEMA approval.
For tornado safe room projects, cost overruns are defined to be additional funds necessary to complete the design and construction of the safe room to FEMA Publication 361 standards. Construction costs in materials continue to rise at indeterminate times. The additional costs may be offset by cost under-runs in other services. The same holds true for all other mitigation construction projects.

Appeals

All subgrantee appeals to FEMA decisions are administered in accordance with implementing program regulations.

A subgrantee may appeal any decision regarding projects submitted for HMA funding. The appeal must be submitted in writing and contain sufficient documentation to support the subgrantee's position. The appeal must specify the monetary figure in dispute and the provisions in Federal law, regulation, or policy with which the appellant believes the initial action is inconsistent. The appeal must reach the Grantee within 60 days from the date the subgrantee was notified of denial of funding.
On behalf of the subgrantee, the State may appeal any FEMA denial for Federal assistance. Within 60 days of the date of the receipt of the appeal from the subgrantee, the State will review the material submitted, make additions if necessary, and forward the appeal with a written recommendation to the FEMA Region VII Administrator.

Quarterly Reports

Quarterly Reports based on the federal fiscal year will be provided to the FEMA Region VII Administrator as required by regulation within 30 days of the quarter end date.

Any problems or circumstances affecting completion dates, scope of work, or project costs which would cause non-compliance with FEMA approved grant conditions shall be described in a letter to FEMA requesting an extension, change in scope of work, etc.

Environmental, Historic, and Floodplain Management Reviews

All projects that involve the floodplain will be coordinated with SEMA's Floodplain Management Section. In addition, the SEMA Mitigation Section will coordinate with other state agencies as appropriate. This coordination will depend on the type of project as required by 44 CFR. For example, project descriptions will be provided to the Department of Natural Resources State Historic Preservation Office for review of potential historic and archeological issues, the Department of Conservation for potential fish and wildlife impacts. In addition, SEMA may use the services of the Department of Transportation for more complex environmental reviews.

Review

Upon completion of a hazard mitigation grant project, the SHMO, Hazard Mitigation Specialist, or other SEMA staff will conduct a closeout site visit to review all files (or a representative sample) and the documents pertaining to the use of 404 and State General Revenue funds when applicable. In addition, all procurement files and contracts to third parties will be reviewed. Worksheets have been created to aid in the closeout review.

All reports generated at the closeout site visit are compared with Request for Funds submitted throughout the duration of the project. Any significant findings are reported to the SHMO for final determination in corrective action. Corrective Action notices will be sent to subgrantees and another site visit will be conducted (if necessary) prior to the release of remaining project funds.

Project Closeout

Upon completion of a HMA grant project, the program manager and/or hazard mitigation grant auditor conducts a closeout site visit to review all files (or a representative sample) and all documents pertaining to the use of HMA grant and state general revenue funds. In addition, all procurement files and contracts to third parties are reviewed. Worksheets have been created to aid in the closeout review.
All reports generated at the closeout site visit are compared with Request for Funds submitted throughout the duration of the program. Any significant findings are reported to the SHMO for final determination in corrective action. If necessary, Corrective Action notices are sent to subgrantees, and another site visit may be conducted if deemed necessary prior to the release of remaining project funds.
Closeout reports will be submitted for each subgrantee upon expiration of the grant. The closeout report will summarize the following:

- Grant Application and Approval Award,
- Procurement,
- Environmental Compliance, if necessary,
- Final Scope of Work Completed (i.e. if a buyout project, the final list of properties acquired),

- Verification of Project Monitoring and Correspondence,
- Summary of Costs Incurred and Reimbursement Received,
- Pictures of work completed, and
- GIS coordinates of the project site.

Closeout reports will generally be submitted 90 days after notification by a quarterly report that the project has been completed. Note: delays could occur due to extenuating circumstances, such as another disaster declaration.

Audit Requirements

44 CFR 14, Administration of Grants: Audits of State and Local Governments, OMB A-133, and the Single Audit Act of 1984, as amended in 1996 all require subgrantees expending $500,000 or more in Federal assistance must have an audit conducted in accordance with the Single Audit Act. Copies of such reports, if applicable, will be requested. All general audit requirements in 44 CFR Part 14 and in accordance with implementing program regulations will be adhered to by SEMA as well as subgrantees spending FEMA hazard mitigation grant awards.

2013 Plan Update

As part of the update to the Missouri State Hazard Mitigation Plan, the previously approved plan's monitoring system for implementation of mitigation measures and project closeout was evaluated. It was determined that the monitoring system described herein to track the initiation, status, and closeout of mitigation activities was taken largely from the former effective Administrative Plan. Therefore, the changes to this section involved incorporating changes that were integrated into the Administrative Plan approved in December of 2010. The SHMO continues to have primary responsibility for continued management and maintenance of the monitoring system. Future reviews will be conducted in accordance with the process and schedules established for the plan maintenance process.

The review of mitigation actions implemented since the last plan update revealed that the mitigation actions were implemented as planned. A description of mitigation actions implemented since the 2010 State Hazard Mitigation Plan development is in Section 4.4.5 Review and Progress of Mitigation Actions. Table 4.4.5.a in that section provides a summary of mitigation actions implemented and estimated funding amounts for 2002–2012. This table demonstrates that the actions implemented fall within the overall State priorities for mitigation.

6.2.2 Progress Review for Mitigation Goals, Objectives, and Activities

A review and update of the State's system for conducting a progress review of mitigation goals, objectives, and actions is also conducted as part of the plan maintenance process. This section includes a description of the State's process for monitoring the progress of mitigation goals, objectives, and actions and any modifications to the system identified during the 2010 plan update.

Mitigation Progress Review System

In order for any program to remain effective, the goals and objectives of that program must be reviewed periodically. That review should answer, at a minimum, the following questions:

- Are the established goals and objectives realistic? (Take into consideration available funding, staffing, state/local capabilities, and the overall state mitigation strategy.)
- Has the State clearly explained the overall mitigation strategy to local governments?
- Are proposed mitigation projects evaluated based on how they help the State and/or local government meet their overall mitigation goals and objectives?
- How have approved mitigation projects complemented existing state and/or local government mitigation goals and objectives?
- Have completed mitigation projects generated the anticipated cost avoidance or other disaster reduction result?

A thorough and realistic evaluation of the benefits of a mitigation project may be delayed until the area of the project is impacted by another disaster. The lack of realized benefits from a completed mitigation project may result in the disapproval or modification of similar projects in the future. At the same time, mitigation projects that have proven their worth may be repeated in other areas of the State.

Based on the results of the review/evaluation of mitigation progress described above, the State may need to adjust its goals and objectives to meet the current and future mitigation needs of the State and local governments. A formal mitigation status report is prepared by SEMA's Logistics, Resources, Mitigation and Floodplain Management Branch on an annual basis. This report is provided to the SEMA director and deputy director for review and distribution, as needed.

2013 Plan Update

For this update to the Missouri State Hazard Mitigation Plan, the system for reviewing progress on achieving goals as well as progress of mitigation activities was evaluated. It was determined that the process stated herein to monitor progress was effective. A few additions and clarifications to this process have been made where warranted. The following paragraphs include additions and modifications to the process initially identified in the 2007 plan updated and implemented during the 2010 plan update.

As part of the 2013 plan update process, the goals and objectives outlined in the 2010 plan were reviewed to determine if they still address current and anticipated future conditions. This was accomplished during a planning meeting and during focused meetings with SEMA mitigation staff. The SRMT evaluated the goals and objectives based on the process outlined above. In addition, the review was based on:

- The updated statewide risk assessment, including changes in development, recent disasters, and analysis of local risk assessments;
- Assessment of changes and challenges in state and local capabilities since the 2010 plan;
- Analysis of the similarities and differences of the state mitigation plan goals with local mitigation plan goals and objectives; and
- Identification of achieved mitigation objectives from the 2010 plan.

This review of the 2010 goals and objectives and modifications to the review process are described in more detail in Section 4.1.2 Process for Identifying, Reviewing, and Updating State Goals and Objectives.

These additional review criteria have been added to the process for reviewing progress on achieving plan goals and objectives.

The status of mitigation actions were also evaluated to ensure that the State is making progress with its overall mitigation strategy. Conducting a comprehensive review of state goals and objectives in conjunction with identified mitigation actions helps ensure consistency with Missouri's overall mitigation goals.

Progress of identified mitigation actions is measured based on the following variables:

- The number of projects implemented over time;
- The successful disbursement of mitigation grant funds over time;
- The disaster losses avoided over time (given a post-disaster event); and
- Plans, partnerships, and outreach developed over time.

There has been significant progress made in the implementation of the State's hazard mitigation strategy since the previous plan update. This has included the completion of 28 safe room projects for a total of $29 million, 16 flood buyout projects for a total of $15.5 million, and eight miscellaneous mitigation projects that cost a total of $4.5 million. SEMA has also continued to coordinate with local jurisdictions, to ensure that local hazard mitigation plans are updated and in effect throughout the State. Technical assistance and funding have been provided where needed.

6.2.3 Staffing

In addition to the duties of the SRMT, SEMA implements and updates the State Mitigation Plan and administers the HMA grant programs using the following positions:

State Hazard Mitigation Officer

The Governor's Authorized Representative (GAR) designates the SHMO. Pursuant to 44 CFR 206.437(b)(2), the GAR identifies the SHMO. At SEMA, the SHMO has overall management responsibility for the mitigation program and is the State official who is ultimately responsible for ensuring that the State properly carries out its Section 404 responsibilities subsequent to a presidential disaster declaration. In this regard, the SHMO monitors and oversees the activities of the Mitigation Specialists, other staff support and the State Risk Management Team. The SHMO coordinates with other SEMA staff and other state executive departments as necessary to ensure the program work required of the State is accomplished to fairly and effectively deliver all Hazard Mitigation Assistance grants to eligible subgrantees.

Hazard Mitigation Specialists

A Senior Hazard Mitigation Specialist and a Hazard Mitigation Specialist assist the SHMO in organizing, coordinating, implementing and administering hazard mitigation projects, including planning projects, and the promotion, direction and evaluation of mitigation issues. The specialists will complete the necessary program work required of the State to deliver the Hazard Mitigation Grant Program to eligible subgrantees. In 2007, the State secured funding to staff a position that is dedicated to providing technical assistance to locals as they develop their hazard mitigation plans. This staff position remains filled, and assistance continues to be provided.

Mitigation Management Team(s)

At various times, for various lengths of time (depending on the workload, complexity, and duration of the plans and projects for the multiple disasters covered by this plan), a management team(s) of the following (full, temp and/or part-time) positions will be filled by SEMA staff, and/or contracted consulting staff, and/or services:

- Hazard Mitigation Specialists,
- Accounting Specialists,
- Emergency Management Officers/Specialists,
- Environmental Specialists,
- Planners,
- Engineers,
- Surveyors,
- Appraisers,
- Real Estate Specialists,
- IT/GIS Specialists/Technicians,
- Legal Specialists,
- Admin Executives/Office Support Assistants
- and other technical and/or fiscal/clerical/admin specialists as needed.

The team(s) will assist the SHMO to manage (organize, promote, coordinate, assist, train, research, analyze, apply, implement, administer, direct, review, prepare and submit etc.) hazard mitigation plans, Benefit-Cost Analyses, projects, issues, outreach, evaluations, Close Out Reports, Success Stories and Loss Avoided Studies, etc. Contracted consulting staff has been procured under SEMA contracts (with annual extension provisions) awarded in 2012. The team(s) continue to support SEMA's program work/activities required to perfect, preserve and deliver the Hazard Mitigation Grant Program (HMGP) assistance provided to eligible subgrantees.

Responsibilities of the SHMO, hazard mitigation staff, and others include, but are not limited to:

- Ensuring the Missouri Hazard Mitigation Grant Program Administrative Plan is updated, outlining how the State will administer the Hazard Mitigation Grant Program and implementing it during a disaster;
- Ensuring that the Missouri State Hazard Mitigation Plan is active, identifying potential hazard mitigation projects, and establishing priorities among those projects;
- Coordinating with the federal hazard mitigation officer in determining the composition of the interagency hazard mitigation team or hazard mitigation survey team when one is established (and its schedule of activities), in estimating the amount of FEMA money available for the Section 404 program, and in administering the program, including submitting required reports to FEMA (all coordination will take into consideration the priorities and procedures as set by the Missouri State Hazard Mitigation Plan);
- Coordinating with state and federal officials to ensure that they understand the involvement of the hazard mitigation effort in the Public Assistance program;
- Ensuring that potential applicants are notified of the mitigation grant programs and receiving the assistance to which they are entitled;

- Developing and implementing a process for identifying potential hazard mitigation projects and for setting priorities among those projects;
- Ensuring that a proper initial application and benefit-cost analysis, and any necessary supplemental applications, including SF-424's, are prepared, coordinated, and submitted in a timely fashion to the FEMA regional administrator;
- Ensuring that technical assistance is provided to potential applicants and/or eligible subgrantees in developing and submitting applications and benefit-cost analyses and in managing and completing approved mitigation projects, to include site visits as necessary;
- Ensuring development of a system to monitor the status of approved projects, for processing extension requests and appeals, and for closing out completed projects;
- Ensuring that adequate procedures are developed for the distribution of financial assistance to eligible subgrantees;
- Ensuring that a system exists to monitor subgrantee accounting systems and compliance with 44 CFR parts 13 and 14;
- Ensuring a computer management system and/or files are maintained for hazard mitigation activities and products;
- Ensuring that appropriate state agencies and divisions are involved as necessary with the hazard mitigation process to include coordination with the SEMA Floodplain Management Section; and
- Ensuring that the required performance reports, such as quarterly progress reports, closeout reports, success stories and loss avoidance studies are prepared and submitted in a timely manner to FEMA.

Other SEMA Staff Involvement

The SEMA director (GAR) and deputy director provide overall guidance, direction, and support for the mitigation program.

The Logistics, Resources, Mitigation and Floodplain Management Branch Chief provides direct supervision of, as well as general guidance, direction, and support for the SHMO who manages the mitigation program.

The Floodplain Management Section performs numerous mitigation related activities, training, and technical support functions that are associated with managing statewide local government participation in the National Flood Insurance Program (NFIP), serving as a state cooperating technical partner in developing and updating floodplain flood insurance rate maps and directly performing flood permitting for all state-owned construction projects. The personnel in the Floodplain Management Section include the floodplain engineer and two floodplain management officers.

The Logistics Section is responsible for developing, managing, and providing SEMA's logistics support and training efforts for local jurisdictions. Mitigation and Floodplain Management Section personnel directly support the Logistics Section during emergency response and then transition to their normal duties during the recovery. However, the performance of the initial disaster logistics needs assessments in the disaster areas enables the participating mitigation staff members to perform a quick assessment of potential mitigation success stories, projects, and the possible need for a dedicated hazard mitigation survey team as well as determine if structures might be substantially damaged. The Floodplain Management and Mitigation Section administrative assistants work under the supervision of the

Logistics Section chief to provide direct daily administrative, clerical, marketing, and database management support for the mitigation program.

SEMA augments the staff in each of the three sections of the Logistics, Mitigation and Floodplain Management Branch as needed with contracted services from Missouri's 19 Regional Planning Commissions (especially planning, planning reviews, project management, and closeout reports), a local engineering firm (for training, surveying, and low cost—mostly floodplain management—minor engineering projects), and a larger engineering firm with a team of partners (mitigation training, benefit-cost analysis assistance, mitigation application development, map modernization program management, complex engineering projects, special projects, etc.). This enables SEMA to surge during times of disaster to more effectively manage larger numbers of mitigation projects and to keep up with the administrative requirements of managing a larger number of mitigation grants.

The mitigation program also is supported by the Fiscal Branch staff as related to the financial aspects of administering the awarded grants for projects and plans through interaction of the grantee (state) with FEMA.

In addition, the mitigation program staff also works in coordination with the Public Assistance staff to determine the feasibility of mitigation projects in support of Public Assistance following disasters.

This plan in its entirety demonstrates the comprehensive nature of Missouri's State hazard mitigation program and provides the foundation for SEMA's Mitigation Section's mission statement, which is:

> "To develop, manage, and administer mitigation programs designed to accomplish activities and projects, develop plans, conduct training and exercises, and provide public education in a manner that promotes public safety and mitigates economic losses, property damage, human injuries, and losses of life from disasters that threaten the State of Missouri."

This enhanced section illustrates how the State continues to take extra steps to commit to mitigation and the creation of safer more-disaster resistant communities throughout Missouri, a commitment that has evolved over multiple decades with the assistance of many groups and individuals, and a commitment that continues to evolve today.

***Technical Note**: This document is a User Interfaced, Web Based Interactive Document. It has been formatted with active embedded hyperlinks throughout. There are several different types of hyperlinks. Hyperlinks within the document: Some of the hyperlinks will direct the user to specific sections of the plan where referenced information may be found. The section heading hyperlinks provided below allow the user to go to a specific section or sub-section of the enhanced plan. In addition, throughout the text, hyperlinks take the user directly to referenced tables, figures, or sections. These links are identified by a blue color format.*

Hyperlinks to SEMA website: Some of the hyperlinks will direct the user to a SEMA website to access reference documents and resource data. Some of these documents are password protected and the user will be directed to obtain credentials from SEMA to gain access. These links are identified by a red color format.

Hyperlinks to external websites: These hyperlinks will direct the user to a third party website where additional information can be found. As with all hyperlinks to external sites, if the site administrator makes changes to the URL, these can expire or become non-functional. These links are identified by a green color format.

This chapter addresses six elements of mitigation planning, consideration of which are critical for a successful mitigation program:

Table 7.0a summarizes the key updates to each of the above elements captured in this chapter.

Table 7.0a Key Updates to the 2013 Enhanced Plan

Section	Element	Update
All of Ch. 7	General Formatting	Formatted the additional information, updates, and changes to conform with the FEMA style guide.
All of Ch. 7	Use of Hyperlinks	Embedded hyperlinks to external websites, resource documents on SEMA website, other plan chapters and sections.
All of Ch. 7	Map Updates	Updated all the maps to reflect changes since the 2010 update.
7.1	Integration with Other Planning Initiatives	Updated the planning documents, included materials relevant to BW-12, updated information regarding floodplain management programs, additional planning programs and initiatives and included.
Figure 7.1	DFIRM Status Map	Updated the map to RISK MAP program statuses for the state.
Table 7.2	Changes to NFIP Participation	Included 2013 data in to the table.
7.2	Project Implementation Capability	No changes with the exception of minor edits to dates and terminology.
7.3	Assessment of Mitigation Actions	No changes with the exception of updating the training programs and dates.
7.4	Effective Use of Available Mitigation Funding	Added updated information to 7.4.2 regarding funding mitigation projects.
Figure 7.2	LAS Methodology	Visual to reflect the phases.
Figure 7.3	LAS Methodology	Visual to show acquisition process
Table 7.4	Declarations since 2010	Updated the table to reflect changes since 2010.
7.5	Commitment to a comprehensive Mitigation Program	Provided updates to the mitigation programs and included and now information as well as updated numbers.
Table 7.6	Mitigation Action Overview	Updated table to reflect changes since 2010
Table 7.7	Mitigation Action Crosswalk	Updated table to reflect changes since 2010
Table 7.8	Summary of Mitigation Actions	Updated table to reflect changes since 2010
Table 7.9	Property Buyout Summary	Added table to show property buyout information by county.
Table 7.10	Safe room Project Status	Added table to show progress of Safe room projects by year and phase.

Requirement §201.5(b):	Enhanced state mitigation plans must include all elements of the standard state mitigation plan identified in §201.4.

The Missouri State Hazard Mitigation Plan contains all the elements required of a standard State mitigation plan. The standard elements are provided in Chapters 1 through 6 of this plan.

7.1 Integration with Other Planning Initiatives

Requirement §201.5(b)(1):	[An enhanced plan must demonstrate] that the plan is integrated to the extent practicable with other state and/or regional planning initiatives (comprehensive, growth management, economic development, capital improvement, land development, and/or emergency management plans) and FEMA mitigation programs and initiatives that provide guidance to state and regional agencies.

The State of Missouri has established a comprehensive State hazard mitigation program that is multi-directional. State mitigation initiatives are integrated with Federal Emergency Management Agency (FEMA) programs and are designed to combine both federal and State programs into local planning efforts. State mitigation planning is also integrated with other State emergency management efforts as well as other State and regional planning initiatives. This section of the plan demonstrates how Missouri's State Hazard Mitigation Plan is integrated with other State and regional planning initiatives and FEMA mitigation programs. It discusses new initiatives that have been implemented since the 2010 plan and integration challenges and successes.

7.1.1 Integration with State Emergency Management Planning Initiatives

The Missouri State Hazard Mitigation Plan is a stand-alone document, but it is closely linked to other SEMA plans. The Missouri State Emergency Operations Plan (SEOP). The SEOP is the emergency management umbrella document, which includes several annexes that focus on specific tasks related to emergency management, such as fire suppression, mass care, and radiological protection. SEMA and the State's Executive Department collaborated on the Catastrophic Event (Earthquake) Annex, which has been added to the SEOP.

The Missouri State Hazard Mitigation Plan is also linked with the Missouri Hazard Analysis. The Hazard Analysis (http://sema.dps.mo.gov/HazardAnalysis/StateHazardAnalysis.htm) is updated annually for use in multiple plans, including the SEOP, and is incorporated into this plan as Section 3.2, Identifying Hazards and Section 3.3, Profiling Hazards.

7.1.2 Integration with National, Regional and Other State Planning Initiatives

Among the extra steps demonstrating Missouri's commitment to mitigation is the continued participation in the National Emergency Management Accreditation Program (EMAP). EMAP is a voluntary assessment and peer-reviewed accreditation process for state and local government programs responsible for coordinating prevention, mitigation, preparedness, response, and recovery activities for natural and manmade disasters. Accreditation is based on compliance with collaboratively developed national standards, the EMAP Standard. The EMAP Standard is based on the 2004 NFPA (National Fire Protection Association) 1600 Standard on Disaster/Emergency Management and Business Continuity Programs. By continuing to comply with the EMAP mitigation standards, Missouri has demonstrated the importance it places on emergency management, including mitigation, and is better prepared to protect its residents and property from hazards.

One of the best examples of the continued integration of State mitigation planning into regional and local planning initiatives from the last several years is SEMA's relationship with Missouri's Regional Planning Commissions (RPCs). Because of the RPCs involvement in the development of local mitigation plans, they are more cognizant of mitigation and can consider the basic principles of mitigation in the other planning efforts they coordinate, including highway planning, comprehensive planning, and capital improvement planning. For example, they can promote regional water interconnects between municipalities to create supply alternatives should a hazard event disrupt this critical utility. This would also serve and support homeland security considerations and requirements. The Bootheel Regional Planning and Economic Development Commission[1] is an excellent example of a well-coordinated effort to further mitigation with a regional approach in Missouri.

The integration of the mitigation plan with other State planning initiatives primarily occurs through the assessment of State capabilities. This occurs in the mitigation planning process through data-sharing between different State plans, and through participation on planning committees and policy commissions. Through the State Hazard Mitigation Planning Team (SHMPT), SEMA planners are made aware of the data, programs, and priorities of other State agencies, and other agencies become more knowledgeable about mitigation policies and programs and how they can be integrated into their own plans.

Specific examples of how the mitigation plan has been integrated with other planning initiatives include the use of earthquake risk assessment results by the Departments of Transportation; Insurance, Financial Institutions, Professional Registration, Corrections; Natural Resources; Education and the Office of Administration as well as the Public Service Commission to develop their earthquake plans. State agencies such as the Department of Mental Health and Department of Social Services have also used information in the mitigation plan to develop and update their emergency operations plans. The Department of Transportation uses mitigation in its capital improvement planning and environmental planning which involves locating facilities, retrofitting bridges, and assessing open space and floodplain issues. The State also considers mitigation in its capital improvements planning (e.g., in designing and siting new facilities). SEMA also participates on the Seismic Safety Commission and provides information for the State's Strategic Plan for Earthquake Safety.

The results of the expanded vulnerability analysis of state-owned facilities in this Mitigation Plan Update have been provided to the Office of Administration, Department of Higher Education, Department of Transportation, and Missouri Department of Conservation (inventories from these sources constitute the full inventory of state-owned facilities in Missouri). For those facilities for which GIS data was provided, the State agencies have been provided with the results indicating specific facilities potentially at risk to inundation from failure of state-regulated dams, flooding from a 100-year flood event, and damage from an earthquake event with a 2% probability of exceedance in 50 years. Provision of this data is provided specifically so that those State-agencies are made aware of potential risks to determine if mitigation opportunities are necessary and/or feasible. Section 3.7 provides additional details as well as password protected hyperlinks to facility-specific risk information.

During the 2013 plan update, the State Hazard Mitigation Planning Team (SHMPT) reviewed the mitigation-related plans and programs of other State agencies. Since response and recovery plans and programs also typically have a mitigation component, the SHMPT also incorporated those plans in this

[1] http://www.bootrpc.com/

review. The purpose of this review was to identify changes, updates, and/or additions since the 2010 Mitigation Plan update to incorporate relevant data and capabilities into the mitigation plan and to better understand areas where mutual responsibilities and policies could be leveraged. Examples of mitigation-related plans and programs of other State agencies participating on the SHMPT are summarized below. The details are provided in Section 4.2.1. Where available, hyperlinks are provided to allow the user to navigate directly to additional information.

- Missouri Seismic Safety Commission Strategic Plan for Earthquake Safety in Missouri, Updated in 2007
- Structural Assessment and Visual Evaluation (SAVE) Coalition Administration and Operations Plan
- Missouri Disaster Recovery Partnership
- Community Organizations Active in Disaster (COAD)
- Missouri Voluntary Organizations Active in Disaster (MOVOAD)
- Missouri Department of Agriculture Catastrophic Mortality and Associated Material Disposal, dated October 2008
- Governor's Faith-Based and Community Service Partnership for Disaster Recovery
- Missouri Department of Conservation (MDC) Statewide Wildfire Control Program
- MDC St. Louis Region Healthy Streams and Watersheds
- MDC Stream Stewardship Trust Fund
- MDC Wetland Restoration Projects
- Department of Economic Development Supplemental Disaster CDBG Programs
- Department of Elementary and Secondary Education Catastrophic Event Preparation
- Department of Health and Senior Services (DHSS) Missouri's Planning Guide for Local Mass Prophylaxis: Distributing and Dispensing the Strategic National Stockpile, dated October 2003(http://www.dhss.mo.gov/BT_Response/SNS_Local_Planning_Guide.doc)
- DHSS Missouri Pandemic Flu Response Plan, dated April 2009
- DHSS Ready in 3 Program
- DHSS Show-Me Response
- Department of Higher Education (DHE) Disaster Resistant University KC Metro Community Colleges
- Department of Insurance, Financial Institutions, and Professional Registration, RSMo 379.795 and 379.978 stipulate earthquake related requirements for insurance companies
- Department of Mental Health (DMH) All Hazards Emergency Operations Plan, dated August 2005
- DMH in partnership with DHSS: Disaster Communication Guidebooks
- Department of Natural Resources (DNR) Dam and Reservoir Safety Program Emergency Action Plan Template
- Central United States Earthquake Consortium (CUSEC)
- DNR Missouri Drought Plan, dated 2002 (http://www.dnr.mo.gov/pubs/WR69.pdf)
- DNR Missouri Water Supply Study, Amended 2009
- DNR State Water Plan
- DNR Stormwater Improvements Program
- Department of Public Safety (DPS) Missouri Fire Marshall's Office –Missouri Systems Concept of Operational Planning for Emergencies (MoSCOPE) dated 2008--standardized method for mutual aid

- Missouri Homeland Security Alert Network
- Department of Social Services Emergency Operations Plan, Children's Division, Dated 2009
- Missouri Department of Transportation (MoDOT) Statewide Transportation Improvement Program, 2011-2015
- Office of Administration-implementation of Archibus including geo-location of state-owned facilities
- Mo Public Service Commission, Missouri Energy Task Force Action Plan, 2006

Missouri Hazard Analysis, November 2011 Integration with FEMA Mitigation Programs and Initiatives

During the development of the 2013 update of this plan, the Biggert Water Flood Insurance Reform Act was passed. Some of the important changes to note are the increase in insurance rates until actuarial rates are achieved, the establishment of a Technical Mapping Advisory council, and the consolidation of mitigation funding programs. As these new reforms are enacted and put into place Missouri will adjust its programs in order to meet the new standards and maximize benefit.

Hazard Mitigation Assistance Grants

The mitigation plan is integrated with FEMA mitigation programs primarily through its mitigation strategy, the local mitigation planning program, and the floodplain management functions. This plan's mitigation actions are described in detail in Section 4.4 and expanded in Section 7.5 later in this chapter. Mitigation Actions are designed to reduce long-term risk in Missouri and improve the State's eligibility for and management of FEMA Hazard Mitigation Assistance (HMA) grant programs listed below:

- Pre-Disaster Mitigation Program
- Legislative Pre Disaster Mitigation
- Flood Mitigation Assistance Program
- Repetitive Loss Program
- Severe Repetitive Loss Program
- Repetitive Flood Claims Grant
- FEMA Public Assistance Mitigation (406)

Through implementation of the FEMA HMA grants, SEMA utilizes information provided in FEMA technical documents related to building construction codes and standards. Specifically, all safe rooms constructed utilizing FEMA HMA grants must be constructed in accordance with *FEMA 361 "Design and Construction Guidance for Community Shelters".*

Local Mitigation Planning

Other actions include helping local governments with their multijurisdictional local hazard mitigation plans (new and updated), which are funded primarily through FEMA's Pre-Disaster Mitigation program and Hazard Mitigation Grant Program, and to provide training and outreach to local governments on the benefits of FEMA mitigation programs and how they can get involved.

Use of Hazus

In updating the Missouri State Hazard Mitigation Plan, SEMA made extensive use of Hazus, FEMA's loss estimation modeling tool, and included the flood and earthquake results in the plan for all Missouri counties. To further integrate the State plan with local plans, SEMA will share these results with local

governments for use in their local mitigation plans. A Portable Document Format (PDF) file is available with the Hazus-generated floodplain for each Missouri County and the City of St. Louis at the following link: PDF Floodplain Maps. In addition to the PDF Floodplain Maps, the Hazus-generated flood data layers are also available at this link.

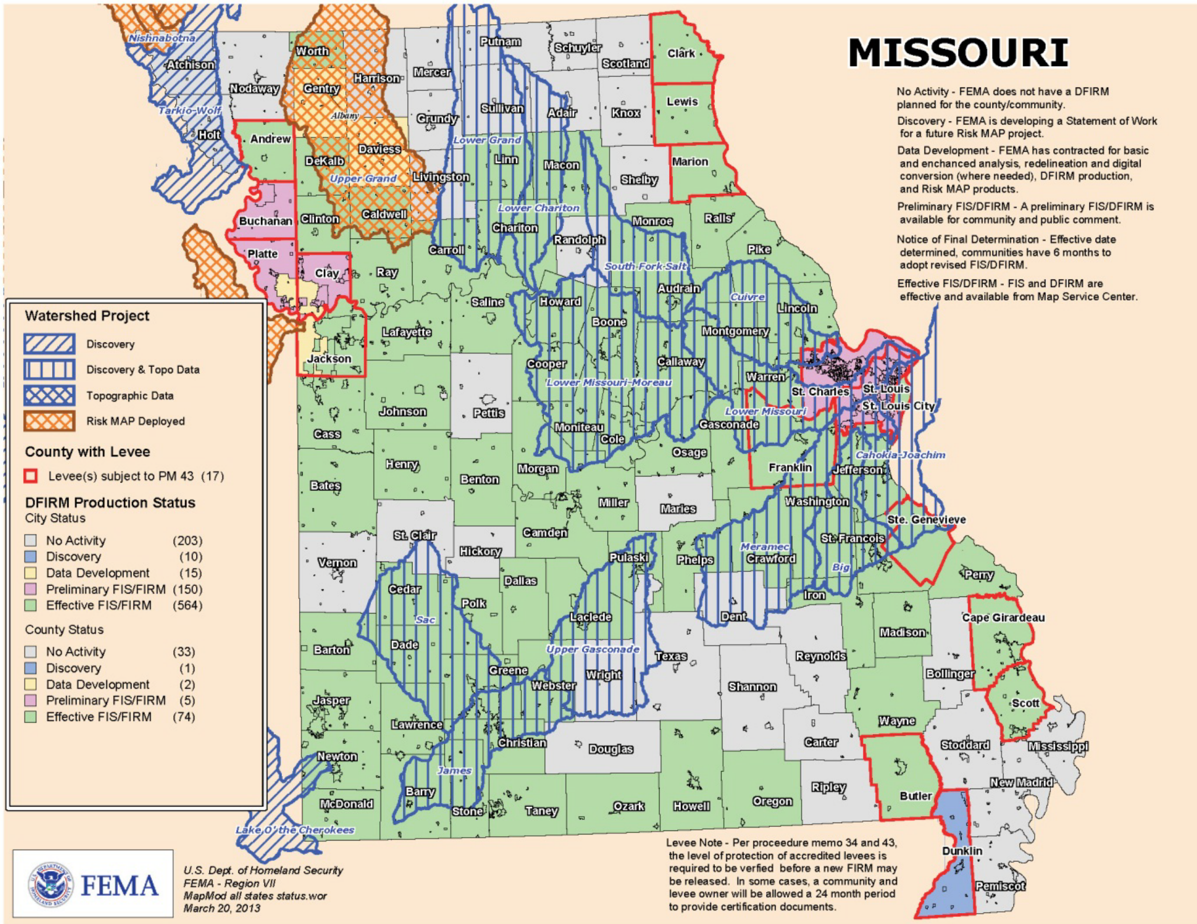
Risk MAP

Risk MAP is an action-driven program through community participation, adopting mitigation planning, communicating risk to citizens, implementing mitigation actions to reduce risk, and utilizing mitigation plans to secure grant funding. Through Risk MAP, FEMA provides information to enhance local mitigation plans, improve community risk awareness outreach, and increase local resilience to flooding. Through collaboration with State, Tribal, and local entities, Risk MAP delivers quality data that increases public awareness and leads to action that reduces risk to life and property.

Missouri is currently in the Risk MAP process to produce digital flood insurance rate maps and supplementary informational products for Missouri counties and incorporated cities. As of March 2013, 74 counties (including 564 cities) have an effective FIRM, 5 counties (including 150 cities) have a preliminary FIRM, and 2 counties (including 15 cities) are in the data development stage (see Figure 7.1.2.1). 60 percent of the counties in the State have either effective or preliminary FIRMS. Funding for this mapping initiative came from a variety of federal, state, and local sources.

This mitigation plan update is linked to the Risk MAP activities within the State through utilization of the FIRM depth grids for 79 Missouri Counties and the City of St. Louis in the Hazus flood risk analysis. By integrated the depth grids generated as part of the FIRMs, the flood risk assessment for these areas is much more accurate. The State intends to incorporate FIRM depth grids for additional counties as they become available.

Figure 7.1.2.1 - DFIRM Status in Missouri as of March 2013



SEMA is currently in the process of developing an Online Flood Visualization Tool. This tool, developed in conjunction with the Online Loss Avoidance Tool described in Section 7.4 will be accessible at the SEMA Website once it is completed. It is estimated that the tool will be available by the end of Semptember 2013. Development of this tool demonstrates the continued integration of Missouri's hazard mitigation plan by communicating the principles of FEMA’s RiskMAP strategy. The tool is a web based flood visualization/awareness tool, integrating digital flood hazard data such as Hazus and DFIRM, in an online mapping environment that allows users to see the extent and depth of the 100 year flood in relation to other layers of digital information such as roads and infrastructure and air photos. Hazus layers that represent the losses to buildings and potentially displaced populations are formatted to be accessible through the web interface. The tool provides a clearinghouse of flood hazard information for use by developers, the insurance industry, government agencies, and the public. This is intended to assist the State, as well as local governments, in their mitigation planning, floodplain management, and flood response efforts.

State Commitment to Floodplain Management

Coordination of the National Flood Insurance Program was transferred from the Department of Natural Resources to SEMA in 1995. Since that time, there has been an enormous effort by State staff to bring

heightened awareness and technical assistance to local communities. SEMA floodplain management staff consists of an engineer, two floodplain managers, one clerk, and a statewide coordinator. This staff coordinates training; joint seminars with the Flood Insurance Administration and an annual workshop. A local guidebook and a quick reference manual were released and hailed a success by local communities and FEMA. Floodplain management enjoys vital day-to-day relationships with the statewide hazard mitigation efforts and staff. Perhaps the most profound change in the State's role in floodplain management and coordination is that State funding has increased over time. The State also encourages local participation in the National Flood Insurance Program (NFIP) and the Community Rating System (CRS.)

According to FEMA's Community Status Book, 48 additional communities have joined the National Flood Insurance Program since January 2010. In addition, the number of communities participating in the NFIPs Community Rating Service (CRS) has doubled. Table 7.1.2a provides additional details on progress made in NFIP participation.

Table 7.1.2a Changes in NFIP Participation, 2007-2010

NFIP Participation	2007	2010	2013
Total in Regular Program	584	604	652
Total in Emergency Program	7	10	2
Total in NFIP	591	614	650
CRS Communities	2	4	62
Mapped Hazard Area, Not in Program	138	118	168
Total Suspended	13	10	2

Source: NFIP Community Status Book January 2010

In July 1997, Executive Order 97-09 was signed by the lieutenant governor authorizing SEMA to issue floodplain permits for any state-owned or leased development in a special flood hazard area. This is accomplished through coordination with the State's Office of Administration the overseas the State's owned and leased assets.

SEMA's Logistics, Mitigation, and Floodplain Management Branch conducts NFIP training. Training courses for the past three years have included the following:

2010

- 1 - NFIP training session for Missouri's Long Term Recovery Committee representatives working with Social Services Block Grants
- 1 – NFIP training session for Mid-Missouri Regional Planning Commission
- 1 – Three-day workshop on water surface profile computations using HEC-RAS with Army Corps of Engineers.
- 3 - NFIP workshops (titled "NFIP 2008 – 2010") for insurance producers, lenders, real estate licensees, brokers, and government officials
- 3 - NFIP for New Floodplain Administrator workshops
- 4 – "Tools of Floodplain Management" two-day workshops
- 2 – "Letter of Map Amendment" (LOMA) workshops

- 4 – “Elevation Certificate” (EC) workshops
- 1 - “Letter of Map Revisions” (LOMR) workshops
- 2 – “Quick2” workshops
- 4 – Certified Floodplain Managers Pre-exam workshops

2011

- 6 - NFIP workshops (titled “Advanced Flood”) for insurance producers, lenders, real estate licensees, brokers, and government officials
- 3 – Two-hour NFIP Basic workshop to FEMA JFO staff
- 1 – NFIP Basic workshop to Area H Coordinators
- 4 – “Tools of Floodplain Management” two-day workshops
- 2 – “Letter of Map Amendment” (LOMA) workshops
- 5 – “Elevation Certificate” (EC) workshops
- 1 - “Letter of Map Revisions” (LOMR) workshops
- 2 – “Quick2” workshops
- 3 – Certified Floodplain Managers Pre-exam workshops

2012

- 4 - NFIP workshops (titled “Flood Insurance Essentials”) for insurance producers, lenders, real estate licensees, brokers, and government officials
- 3 - NFIP for New Floodplain Administrator workshops
- 3 – “Tools of Floodplain Management” two-day workshops
- 2 – “Letter of Map Amendment” (LOMA) workshops
- 6 – “Elevation Certificate” (EC) workshops
- 2 – “Letter of Map Revisions” (LOMR) workshops
- 2 –“ Quick2” workshops
- 4 – Certified Floodplain Managers Pre-exam workshops

SEMA continues to administer the Certified Floodplain Manager exam and as of May 2013, there are a total of 147 CFMs in Missouri. Additionally, SEMA annually attends and sponsors the Missouri Association of Floodplain and Stormwater Managers Association annual conference as well as the National Association of State Floodplain Managers conference.

7.2 Project Implementation Capability

Requirement §201.5(b)(2)(i) and (ii):	[The enhanced plan must document] the state’s project implementation capability, identifying and demonstrating the ability to implement the plan, including: • Established eligibility criteria for multi-hazard mitigation measures. • A system to determine the cost-effectiveness of mitigation measures, consistent with OMB Circular A-94, Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs, and • [A system] to rank the measures according to the state’s eligibility

criteria.

Over the years, the State has developed and demonstrated mechanisms to implement mitigation plans and projects, including this Missouri State Hazard Mitigation Plan and the processes explained herein. SEMA has established criteria for projects, including multi-hazard considerations. SEMA uses FEMA's recommended benefit-cost analysis system to determine if potential mitigation activities are cost-effective and assigns priority to potential mitigation activities.

This section describes the Missouri State Hazard Mitigation Plan's eligibility criteria and procedures for determining the cost-effectiveness of mitigation measures. It also demonstrates how Missouri addresses the effectiveness and adequacy of the State's established eligibility criteria for multi-hazard mitigation actions; the effectiveness of its system for determining cost-effectiveness of those actions consistent with OMB Circular A-94, *Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs*; and the effectiveness of its approach to using cost-effectiveness as part of its eligibility criteria.

In addition, this section also describes how the State evaluates cost-effectiveness The procedures for this evaluation are consistent with Missouri's Hazard Mitigation Grant Program Administrative Plan, It is now the responsibility of each local government submitting a grant application to perform a benefit-cost analysis (BCA) for projects. SEMA trains applicants on how to perform BCAs using FEMA software and then reviews the application submittals for accuracy and cost-effectiveness. SEMA also recruits the assistance of RPCs in providing BCA assistance to local jurisdictions.

Effectiveness is based on the fact that over 90 percent of projects submitted have been funded, and potential losses were avoided in cases where a hazard affected a project site after its completion, e.g., significant savings were realized following the 1995 floods that succeeded the 1993 post-flood buyouts. Additionally, the national Multi-hazard Mitigation Council report, *Natural Hazard Mitigation Saves: An Independent Study to Assess the Future Savings from Mitigation Activities* (2006), determined that mitigation projects, nationwide, are providing a return on investment (ROI) of 4-to-1. For more information about loss avoidance in Missouri, see Section 7.4.2 Post-disaster Progress Assessment/Review of Mitigation Goals, Objectives, and Measures and the summary document *Past Mitigation Projects* which compiles all past mitigation projects by project type.

7.2.1 Process Used to Evaluate and Prioritize Mitigation Actions

This section explains the process used to evaluate and prioritize mitigation actions. Local jurisdictions are strongly encouraged to incorporate mitigation actions, based on established natural hazard risk assessments, into all proposed development projects and as improvements to existing projects.

Funding will always be an important issue when considering mitigation actions. Generally mitigation funds are limited to the Hazard Mitigation Assistance grants. These programs are the Pre-Disaster Mitigation Program, Flood Mitigation Assistance Program, Hazard Mitigation Grant Program, Repetitive Flood Claims Grant, and Severe Repetitive Loss Program. SEMA also uses FEMA's Public Assistance Program (Categories C-G) to implement mitigation activities. All these grant programs are non-disaster (annually funded) grant programs except the HMGP and Public Assistance Program which are post-disaster programs. To fairly and efficiently utilize these grant programs to achieve mitigation across the

State, a sound process has been developed to evaluate and prioritize proposed mitigation actions so that limited grant funds are used most effectively in Missouri.

SEMA has the primary responsibility for reviewing and evaluating mitigation projects submitted by local jurisdictions. The SHMPT may also be involved in the event of a large disaster. Broadly, SEMA uses the STAPLEE (social, technical, administrative, political, legal, economic, and environmental) criteria in evaluating mitigation projects and the following criteria to assess the mitigation actions depending upon the current situations and threats:

- Flood mitigation projects (repetitive loss properties high priority)
- Tornadoes and high wind mitigation projects
- Earthquake mitigation projects
- Other, not direct life safety

STAPLEE is used as a screening tool to determine if the project makes sense and is worthy of consideration and implementation. During the 2010 update, SEMA utilized a modified STAPLEE scoring system to evaluate all mitigation actions that were identified in the mitigation strategy. This method of scoring was continued into the 2013 plan update. See Section 4.4.2 for a more detailed discussion.
Specifically, SEMA uses the following list of questions to help guide the distribution of mitigation project funds:

- What is the hazard to be mitigated?
- Does the applicant have a FEMA-approved mitigation plan?
- Does the project complement State and local mitigation goals and objectives identified in the mitigation plans?
- Is the hazard being mitigated a priority hazard in the applicant's mitigation plan?
- Is the project cost-effective based on FEMA's benefit-cost analysis module?
- Does the project have the potential to substantially reduce the risk of future damage, hardship, loss, or suffering that may result from a major disaster?
- Does the project result in mitigating flood damage to repetitive loss or severe repetitive loss properties?
- In the past, what mitigation efforts were undertaken by the applicant using local funds and initiatives and what were the outcomes?
- What is the applicant's disaster history?
- Are sufficient mitigation funds available to complete the project?
- Does the applicant have sufficient funds (if other funds are not available) to meet the local share of the project?
- Does the applicant have the capabilities to complete the project as submitted?
- Does the project independently solve a problem?
- Does the project have the potential to have a larger impact on the local and State mitigation program than other submitted projects?
- Does the project reduce impacts in an area experiencing growth and development pressures?
- Does the project have any negative impacts on neighboring communities?

When funding comes from the Hazard Mitigation Grant Program (post-disaster funding), priority is given to mitigation projects related to the hazard that necessitated the disaster declaration and those jurisdictions included in the disaster declaration.

This plan does not differentiate or classify mitigation initiatives as primary or secondary. Mitigation initiatives will be evaluated and prioritized based on the criteria described above. Any mitigation project that is approved for funding is done so on the basis that it will benefit the community at large and, therefore, the State.

Information on this process is also included in Section 4.4.2 Process for Identifying, Evaluating, Prioritizing, and Updating Mitigation Actions and Section 5.3.2 Project Grants.

7.2.2 Eligibility Criteria for Multi-hazard Mitigation Projects

This section of the plan addresses the eligibility criteria for multi-hazard mitigation projects. The criteria listed in this section are the basic criteria for each type of project. These criteria may be modified based on any of the following issues:

- The specific disaster situation
- Location of affected areas
- Availability of funds
- Unique program requirements of the fund source
- Current State and/or local hazard mitigation priorities
- Number/type of mitigation projects submitted by local governments

All hazard mitigation projects submitted for HMGP funding consideration must meet the criteria outlined in 44 CFR 206.434. To meet FEMA's minimum hazard mitigation project criteria, the project must:

- Be in conformance with the hazard mitigation plan developed as a requirement of Section 322
- Have a beneficial impact upon the designated disaster area, whether or not located in the designated area
- Be in conformance with 44 CFR 9, Floodplain Management and Protection of Wetlands, and 44 CFR 10, Environmental Considerations
- Solve a problem independently or constitute a functional portion of a solution where there is assurance that the project as a whole will be completed (projects that merely identify or analyze hazards or problems are not eligible)
- Be cost-effective and substantially reduce the risk of future damage, hardship, loss, or suffering resulting from a major disaster

The project must also meet the following State criteria:

- The project must complement existing or proposed State mitigation goals and objectives
- The project must complement existing or proposed mitigation goals and objects for the jurisdiction submitting the project
- The jurisdiction requesting the project must be able to complete the project as submitted

- The jurisdiction submitting the project must be able to meet any matching funds requirements (if required)
- The project must be able to make a bigger impact on the local and State mitigation program than other non-selected projects

The systems in place continue to work well; therefore, the 2013 update did not add or eliminate any of the eligibility criteria or alter the system for determining the cost-effectiveness of mitigation actions.

7.2.3 Eligibility Criteria by Mitigation Project Type

SEMA considers many types of projects to be eligible for mitigation, in particular the 11 "M" action categories identified in Section 4.4 Mitigation Actions. All projects must be in conformance with at least one of these mitigation action categories. Flood mitigation projects continue to be the State's highest priority, followed by tornado projects and finally earthquake projects. Among the actions that mitigate these hazards, those that provide for or protect life safety are given the highest priority.

Flood Mitigation Projects

In each type of flood mitigation project discussed below, homeowner participation must be voluntary and the homeowner must be able to prove ownership of the property involved in the project.

Property Acquisition

While buyouts are not the only mitigation projects considered and undertaken by the State and local governments, they have been the type of projects most frequently submitted and approved. Voluntary property acquisition is SEMA's most successful, and usually most cost-effective, mitigation project, because the people and property are totally and permanently removed from flooding danger.

In general, SEMA works with local governmental entities to acquire and remove, elevate, relocate, or perform minor structural projects on privately owned residential structures and/or privately owned lots that are located in the floodplain and/or floodway. In addition to the requirements listed in the previous section, these projects must also meet the following criteria:

- The project chosen must independently solve or be a functional part of a solution to a problem that is repetitive or poses a significant risk to health and safety. The proposed solution must be the most practical, effective, cost-effective, and environmentally sound alternative among a range of alternatives that contribute to a long-term solution of the problem
- Local governmental entities (and certain private nonprofit entities) must apply through the State, specifically SEMA, to FEMA for funding to perform a project or projects. The applications must specifically identify the properties to be included in the project or projects. All projects must be proven cost-beneficial in accordance with a determination method that is acceptable to SEMA and FEMA (e.g., FEMA's benefit-cost analysis software)
- Local governmental/nonprofit entities must be in good standing in the National Flood Insurance Program (or have not yet been mapped) and otherwise eligible to receive federal funding. Nonfederal matches and all other federal grant requirements must be satisfied by the local entity, sometimes with monetary assistance from local property owners or possibly SEMA or the Missouri Department of Economic Development

- Hazard Mitigation Grant Program, Pre-Disaster Mitigation, Flood Mitigation Assistance, Repetitive Flood Claims, and Severe Repetitive Loss projects must be consistent with the Missouri State Hazard Mitigation Plan. Projects must also conform to 44 CFR 9, Floodplain Management and Protection of Wetlands, and 44 CFR 10, Environmental Considerations
- Only local governmental/certain nonprofit entities, eligible special districts, or contractors representing these applicants may manage the project or projects. All projects must be managed in accordance with local, state, and federal ordinances, laws, and regulations. Individual property owners are not eligible to receive federal funds directly as a grantee or subgrantee and are not authorized to manage grant projects

To be eligible to participate, the local governmental/nonprofit entity must agree to the following:

- The offer is based on pre-flood fair market value determined by a State board-certified appraiser or a post-flood sales contract value
- Duplication of Benefits, Small Business Administration loans, and private mortgages must be satisfied from proceeds first
- The buyout property must be demolished within 90 days of the closing
- Local governmental entities, and certain nonprofit entities, must accept all buyout property titles, which are officially annotated to comply (in perpetuity) with federal open space deed restrictions. SEMA verifies that the appropriate restrictions have been put in place as part of the project closeout process
- The buyout property becomes ineligible for any future federal disaster assistance, except possibly Federal Crop Insurance

Currently, it is SEMA policy that there will be no acquisition of commercial properties due to the generally higher expense.

Elevation

Elevation is a voluntary option that may be used if it is the more cost-effective and desirable option in the long run (e.g., when the cost of the land is so high that a buyout is impractical). To be eligible to participate, the local governmental/nonprofit entity must agree to the following:

- The elevation project must be a practical, cost-effective, and structurally sound alternative (in compliance with local building code and zoning rules) that elevates the lowest floor to an elevation at or above the base-flood elevation (BFE, also equivalent to water surface elevation of the 1 percent or 100-year flood) or to an elevation that complies with local floodplain management regulations, if more stringent, by:
  - Extending the walls of the house upward and raising the lowest floor (where appropriate, such as within an area with a moderate or greater earthquake risk, SEMA adds multi-hazard stipulations, e.g., requiring shear walls as part of an elevation project)
  - Converting the existing lower area of the house to non-habitable space and building a new second story for living space
  - Lifting the entire house, with the floor slab attached, and building a new foundation to elevate the house
- In A zones, property owners may elect to elevate buildings either on fill, an open foundation, or on continuous foundation walls that extend below the base-flood elevation. If continuous walls

are used below the BFE, they must be equipped with openings that allow floodwaters to flow into and out of the area enclosed by the walls

- Owners of substantially damaged homes in special flood hazard areas (SFHA) must be willing to relocate outside the SFHA, or voluntarily demolish the remnants of the house and build a new house on the same site with an elevated lowest floor at or above the BFE or at an elevation that complies with local floodplain management regulations, if more stringent. In most instances, demolition/rebuild does not qualify for grant assistance
- Alternatively, owners of substantially damaged houses in special flood hazard areas may elect to repair the house and elevate the lowest floor at or above the BFE or an elevation that complies with local floodplain management regulations, if more stringent, as part of the repair process

Relocation

Relocation is a voluntary option that may be used if it is more practical/cost-effective or when the threat is so repetitive and/or severe that it is more advantageous to relocate a structure or structures, up to and including entire communities, entirely out of harm's way. Relocation is also an alternative to rebuilding following a declaration of substantial damage. To be eligible to participate, the local governmental/nonprofit entity must agree to the following:

- Structures relocated from acquired property must be placed entirely outside the 100-year floodplain
- Generally, structures must be relocated from acquired property within 90 days of closing
- Ownership of acquired real property may not be conveyed to private citizens or entities; ownership may be conveyed to other public entities or nonprofit organizations with the approval of the State and FEMA
- Local governmental entities, and certain nonprofit entities, must accept all buyout property titles, which are officially annotated to comply (in perpetuity) with federal open space deed restrictions
- Any buyout property (i.e., any vacated lots acquired through the project) becomes ineligible for any future federal disaster assistance, except possibly Federal Crop Insurance

Floodproofing

Floodproofing is a voluntary option that may be most practical in limited areas. To be eligible to participate, the local governmental/nonprofit entity must agree that this measure will best remove the danger to the property. To be eligible, the following must apply:

- The property is in an area that is not subject to flash flooding
- Extensive cleanup normally is not required after a flood event
- One of the two floodproofing processes described below is the most advantageous measure to employ in the long run
  - ***Wet floodproofing*** allows water to enter the structure, thereby equalizing pressure on walls and floors. Building contents such as furnaces and appliances are relocated out of reach of the floodwater
  - ***Dry floodproofing*** is a process that uses waterproofing compounds, sheeting, or other impermeable materials to prevent floodwaters from entering the structure. To maintain consistency with National Flood Insurance Program regulations, FEMA will not fund dry floodproofing of residential structures. FEMA may fund dry floodproofing of commercial

structures, but protection must be up to at least one foot above the BFE or an elevation that complies with local floodplain management regulations, if more stringent.

Structural Mitigation Projects

Structural mitigation projects are most often infrastructure type projects sometimes associated with FEMA's post-disaster Public Assistance (PA) program. To be eligible for funding for structural mitigation projects, a jurisdiction and the project must meet all of the criteria of the federal/state public assistance program. Those criteria include, but are not limited to, the following:

- The project is required as a result of the declared event;
- The project is within the designated disaster area;
- The project is the legal responsibility of an eligible applicant.

When these stipulations are met, a community can incorporate improvements into the repair or replacement of a damaged facility (e.g., replace a damaged culvert with a larger one, as long as it can be demonstrated to be technically feasible, cost-effective, and environmentally sound). There are other types of structural flood mitigation projects that can be promoted and encouraged in addition to those achieved through the PA program. For example, structural flood mitigation projects such as drainage improvements or low-water bridge crossings don't require a disaster declaration or damage to a specific facility.

Tornado Mitigation Projects

In addition to the relevant requirements for flood mitigation projects, tornado safe rooms and other similar mitigation measures that protect people from tornadoes and high winds, must comply with FEMA publications *Taking Shelter from the Storm: Building a Safe room Inside Your House* (320) and *Design and Construction Guidance for Community Shelters* (361). Only eligible construction-related costs will be reimbursed by FEMA.

Earthquake and Other Mitigation Projects

The majority of Missouri's approved mitigation projects have resulted from flood-related disasters. The recent frequency of tornadoes has made tornado safe room projects the next most frequent type of mitigation project sought. Other projects listed below may also be approved depending on the availability of funds, state and local priorities, and proof of benefit-cost and project submissions:

- Burial of power lines underground
- Structural seismic retrofit of undamaged critical facilities
- Nonstructural seismic retrofit of undamaged critical facilities (such as filming windows, strapping and bracing equipment, etc.)
- Development of educational programs and materials
- 5% State Initiative Projects

SEMA promotes a project identification framework from the NFIP's CRS. The following six types of mitigation categories emphasize flood solutions; however, they can also be applied to other natural hazards:

- Preventative measures
- Structural projects

- Property protection measures
- Emergency services
- Natural resource protection
- Public information/education projects

7.2.4 Pre-Project Determination of Cost-Effectiveness of Mitigation Measures

A key criterion for mitigation projects to be eligible for funding is that they must be cost-effective. If the project benefits are higher than the project costs, then the project is cost-effective. The purpose of this section is to address the process used by the State to determine the cost-effectiveness of mitigation actions. The only change to this process since the 2007 Mitigation Plan update is the utilization of FEMA's updated benefit-cost analysis software. Other than incorporating the updated software, changes to the process to determine cost-effectiveness of mitigation measures has not changed since the 2007 Mitigation Plan update.

In order to ensure a consistent approach in determining the cost-effectiveness of all mitigation projects, the State uses FEMA's BCA module and process, which is consistent with OMB Circular A-94, *Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs*. Since this is the method developed and used by FEMA to determine the cost-effectiveness of a project, it is reasonable for the State to use the same method. A BCA assesses a mitigation project based on the project, hazard, and benefit data provided in a grant application. SEMA encourages applicants to pre-screen their proposed mitigation projects by using an upper-bound analysis, so an early determination of cost-effectiveness can be made. Upper-bound analyses are also used to identify projects that are not cost-effective.

When funding is available SEMA organizes annual grant mentoring workshops, one for each grant cycle, to help local governments develop Hazard Mitigation Assistance subgrant applications, benefit-cost analyses, and eGrant (Electronic Grant Application) applications. This includes the non-disaster (annually funded) grant programs of PDM, FMA, RFC, SRL, and the post-disaster grant program – HMGP. The workshops assist local governments and RPC planners with their applications. In 2009 alone, SEMA held two workshops and trained approximately 50-60 people.

It is understood that a positive benefit-cost ratio (greater than one) does not necessarily guarantee that a hazard mitigation project will be approved. However, by applying project specific information to the benefit-cost analysis module it is possible to get a good look at the mitigation potential associated with a project. The results of this analysis can also help communities evaluate current and future mitigation projects and adjust their overall mitigation strategy accordingly.

The following information serves to summarize the three-step process for determining a mitigation project's cost-effectiveness. This process is used for determining the cost-effectiveness of all HMA project applications regardless of the type of mitigation measure.

1) Screen Project Application Data

The first part of the process is screening the project application to gather data related to cost-effectiveness. This includes economic, environmental, and engineering data. This data is often missing or limited. The amount of data available will determine the type of benefit-cost analysis used. The screening process involves three separate but related tasks. Each task is conducted simultaneously and is essential to developing an overall profile of the project before conducting the benefit-cost analysis.

- **Engineering Review**—This review, conducted by the applicant, establishes whether the project is feasible from an engineering standpoint and whether it will reduce damage as claimed. The reviewer may suggest changes to make the project more efficient in reducing damage and loss.
- **Environmental Assessment**—This part of the screening process alerts reviewers to any potential environmental concerns raised by the project.
- **Project Application Data Review**—This part of the screening process determines whether the application contains sufficient information and data for input into the benefit-cost model (see Table 7.2.4a).

Table 7.2.4a shows the basic data that must be obtained from hazard mitigation applications before a benefit-cost analysis can be performed. This data is plugged into the benefit-cost module to determine whether the project is cost-effective or not. The examples below are key data used for analyzing flood, tornado, and earthquake hazard mitigation projects. Nevertheless, the same basic information and analysis is needed for mitigation projects related to any type of hazard.

Table 7.2.4a Key Data Needed for Analyzing Project Applications

Subject	Flood Project Data	Tornado Safe room Project	Earthquake Project Data
Hazard Data (often not included in application)	Flood insurance study data or historical flood data from application	Wind speed Zone	Seismic hazard data from a credible source
First Floor Elevation	Is this available from engineering surveys or can it be estimated from observed flood depths?	Not applicable	Not applicable
Scope	What problem does the project address? How vulnerable is the building, item, or area?	Same as flood	Same as flood
Cost	Is there a well-documented cost-estimate or only a rough estimate?	Same as flood	Same as flood
Useful Lifetime	How long will the project provide protection (mitigation) against damage and losses?	Same as flood	Same as flood
Economic Considerations	What is the square footage of the building? What are the replacement values of the building (or other facility) and contents?	Not applicable	Same as flood
Occupancy	Not usually applicable	Occupancy by hour	What are the levels of occupancy and visitors during various times throughout the day?
Function	What is the function of the facility and is it entirely or partially related to emergency response and recovery?	Same as flood	Same as flood

Subject	Flood Project Data	Tornado Safe room Project	Earthquake Project Data
Damage Estimates—Before Mitigation	• What type of building is it? • Why does damage occur? • What is the historically-observed damage?	Not applicable (life safety mitigation)	• Same as flood • Are engineering reports available that describe building/ facility seismic vulnerabilities?
Damage Estimates—After Mitigation	How effective will the mitigation project be in reducing future damage? (Reduced damage can be percent or dollar values)	Not applicable (life safety mitigation)	Same as flood

2) Conduct a Benefit-Cost Analysis

The second part of the process is determining which benefit-cost analysis tool to use. Ideally, the project application contains all the data needed. However, project applications often have incomplete or limited data. This is one of the main reasons that a streamlined process was developed to determine project cost-effectiveness without all data included. It is also the reason that federal, state, and local mitigation specialists must work closely together to ensure that all proposed mitigation projects are thoroughly reviewed and comply with the mitigation goals and objectives. For applications that don't have all required information, because some required information may not exist or be available, FEMA has developed several shortcuts that allow a benefit cost analysis to be conducted with limited information.

Screening the project data (step 1) helps determine which type of analysis to perform. If the project application data are limited or incomplete, then a benefit-cost analysis that uses limited data should be employed. If, however, the data in the project application are more or less complete, then a more robust method of analysis can be used.

A Benefit-cost analysis must be used for all cost-effectiveness determinations. At its most basic level, benefit-cost analysis determines whether the cost of investing in a mitigation project today (the "cost") will result in sufficiently reduced damage in the future (the "benefits") to justify spending money on the project. If the benefit is greater than the cost, then the project is cost-effective; if the benefit is less than the cost, then the project is not cost-effective. The benefit-cost ratio (BCR) is a way of stating whether benefits exceed projects costs, and by how much. It is figured by dividing the benefits by the costs. If the result is 1.0 or greater, then the project is cost-effective.

Example 1: The project cost is $1,000, and the value of damage prevented after the mitigation measure is $2,000. The BCR ($2,000/$1,000) is 2.0. Because the dollar value of benefits exceeds the cost of funding the project, and the BCR is greater than 1.0, the project is cost-effective.

Example 2: The project cost is $2,000, and the value of damage prevented after the mitigation measure is $1,000. The BCR ($1,000/ $2,000) is of 0.50. Because the cost of funding the project exceeds the dollar value of the benefits, and the BCR does not meet the 1.0 required for cost-effectiveness, the project is not cost-effective.

While these examples are oversimplifications, the process and the associated benefit-cost analysis calculations are basically the same for all mitigation projects. It is important to understand that benefit-

cost analysis is essentially the same for each type of hazard mitigation project. The only differences are the types of data that are used in the calculations. The types of data depend on whether the project is for floods, tornadoes, or earthquakes.

Three approaches are used to determine a project's benefit-cost ratio: lower-bound analysis, upper-bound analysis, and best estimate. The lower-bound and upper-bound methods are used in many cases to make final determinations of cost-effectiveness when there is limited data. In other cases, quick screening analysis with these approaches yields inconclusive results and additional data and screening may be required. Best estimate analysis produces the most accurate results.

Lower-Bound Analysis

Lower-bound analysis is a powerful tool that can demonstrate that projects are cost-effective even if the available data is not complete. A project's cost-effectiveness can sometimes be determined by using only one or two key pieces of data. The lower-bound analysis was developed with this in mind.

The lower-bound analysis considers only some of a project's benefits (those that are the most important or those for which data exist) and ignores other benefits that may be difficult to estimate or for which data may not be available. In other words, this analysis purposely uses only a few pieces of information and undercounts, or ignores other benefits that may be gained by implementing the project. If results indicate that a project is cost-effective, then no further analysis is needed and no additional data has to be collected.

Lower-bound analysis at a glance:

- It should be used when data is incomplete
- It can determine that a project is cost-effective
- It cannot determine that a project is not cost-effective
- It uses data for one or two significant benefits

Upper-Bound Analysis

If a lower-bound analysis shows that a project is not cost-effective, then the next step is an upper-bound analysis. Sometimes an upper-bound analysis is used if, at first glance, the project appears not to be cost-effective. Like lower-bound analysis, upper-bound analysis relies on limited project data. Upper-bound analysis, however, also uses professional judgment to estimate which input data produce the highest reasonable benefits.

It is extremely important to note that upper-bound analysis cannot determine if a project is cost-effective because it relies on the highest reasonable estimate of benefits. An upper-bound analysis can only determine whether the project BCR is less than 1.0 and thus not cost-effective.

Upper-bound analysis at a glance:

- It can only determine that a project is not cost-effective
- It is used as the next step if the lower-bound analysis is negative (not cost-effective)
- It is used if a project appears, at first glance, unlikely to be cost-effective

- It uses the highest reasonable estimate of benefits for a project
- It analyzes as many inputs as possible, assigning the highest reasonable value to each

Best Estimate Analysis

A best estimate analysis is used when the project application data is complete, or almost complete. This analysis provides a more accurate BCR than either lower- or upper-bound, because it considers more data in the analysis. As discussed earlier, in many cases lower-bound or upper-bound analysis can provide firm decisions about cost-effectiveness without requiring as much data as a best estimate analysis.

A best estimate analysis can determine if a project is either cost-effective or not, because all significant data are considered. Because this method of benefit-cost analysis provides the best estimate of cost-effectiveness, it can be used to rank or set priorities among competing projects. Neither lower-bound nor upper-bound analysis are used to rank or set priorities among projects. They do not consider enough data to determine accurate BCRs; they only produce "bounds" on BCRs (i.e., BCR > 1.0 or BCR < 1.0).

Best estimate analysis at a glance:

- It should be used when the project application data is complete, or almost complete
- It produces a more accurate analysis than lower-bound and upper-bound analyses
- It determines whether a project is cost-effective or not cost-effective
- BCR can be used for ranking or setting priorities among projects

3) Review the Results of Benefit-Cost Analysis

The final step of the review process is to determine whether a project is cost-effective or whether further analysis is required. There are three possible outcomes to a benefit-cost analysis: the project is deemed cost-effective (BCA > 1.0), the project is deemed not cost-effective (BCA < 1.0), or additional data may be required.

Typically, if the project is cost-effective as determined by a lower-bound or best estimate analysis, then no further analysis or additional data collection is required. Then the application moves to the next level in the funding process. If the project is not cost-effective as determined by an upper-bound or best estimate analysis, then no further analysis or additional data collection is required and the project is rejected. In some cases, additional information may be requested, or the applicant may be shown how the mitigation effort can be redirected. In general, for the Pre-Disaster Mitigation grant program, it is an advantage to maximize benefits (e.g., BCA > 1.0) to make the application more competitive.

If the cost-effectiveness of a project cannot be determined, then additional data must be collected. It is important to recognize that only the minimum data necessary to reach a decision on project cost-effectiveness must be collected. In many cases, the collection of one or two pieces of information is sufficient to reach a decision. A complete analysis is conducted for those relatively few cases where the BCA is close to 1.0.

7.3 Program Management Capability

Requirement §201.5(b)(2) (iii A-D):	[The enhanced plan must demonstrate] that the state has the capability to effectively manage the HMGP as well as other mitigation grant programs, [and provide] a record of the following: • Meeting HMGP and other mitigation grant application timeframes and submitting complete, technically feasible, and eligible project applications with appropriate supporting documentation; • Preparing and submitting accurate environmental reviews and benefit-cost analyses; • Submitting complete and accurate quarterly progress and financial reports on time; and • Completing HMGP and other mitigation grant projects within established performance periods, including financial reconciliation.

According to FEMA's *Multi-Hazard Mitigation Planning Guidance under DMA 2000*, "FEMA regional offices will certify that the State has the capacity to effectively manage the HMGP, FMA, and PDM programs. The State is not required to document this in their plan." However, the State offers the following narrative to assist in documenting Missouri's continuing capability to effectively manage Hazard Mitigation Assistance Grants.

7.3.1 State Capability for Hazard Mitigation

Since Section 322 of the Disaster Mitigation Act of 2000 provides for a significant increase in Hazard Mitigation Grant Program (HMGP) funding available to the State, it is critical that the State demonstrate its ability to manage the HMA grants and its commitment to mitigation.

The following factors were initially developed by FEMA for considering a state for "managing state" status. Missouri meets all of these requirements and was initially designated as a "managing state" for hazard mitigation in February 2001.

Past Performance of the State

Missouri's Hazard Mitigation Grant Program (HMGP) Administrative Plan, quarterly reporting system, and HMGP applications have all been used as models for other states as well as FEMA headquarters. The Hazard Mitigation Grant Program Administrative Plan developed by SEMA in 1995 was one of the first procedural plans developed that addressed additional elements not required by the Code of Federal Regulations. In addition, Missouri's standard HMGP buyout application and quarterly reports were requested by FEMA headquarters to use as the National Emergency Management Information System standard.

Missouri consistently provides quarterly reports on time. Missouri maintains a record for meeting all HMA grant application timeframes, utilizing allowed and approved extensions only when necessary.

When extensions to timeframes are deemed necessary or critical, the State has consistently requested such extensions prior to lapse of initial timeframes.

The State of Missouri has conducted the following grant orientation meetings since July 2010 as part of their project implementation process:

Grant Orientation Dates July 2010 – July 2013

2010

8/26/10:	University City Buyout
8/31/10:	Jefferson County Buyout
9/17/10:	Bloomfield R-XIV, Monett R-I
9/23/10:	St. Charles County Buyout
10/4/10:	Hannibal Buyout
10/30/10:	Archie R-V, Springfield Public School District
11/30/10:	Marquand-Zion R-VI
12/9/10:	City of Clayton Buyout
12/16/10:	Marble Hill Buyout

2011

1/3/11:	Smithville R-II
2/8/11:	Ferguson Buyout
6/14/11:	Jasper County School District, Texas County Memorial Hospital
7/5/11:	Clever R-V, East Newton County School District
7/8/11:	St. Louis County (Bon Oak) Buyout
7/11/11:	Springfield (Upper Wilson Creek) Buyout
8/1/11:	Fair Grove
8/5/11:	Webster County - Leabrooke
8/18/11:	Fredericktown, Marshfield School District, Moberly Area Community College – Hannibal, Republic R-III
9/12/11:	Nixa R-II
10/19/11:	Independence Power & Light
11/17/11:	Wayne County Buyout
12/16/11:	Cape Girardeau County (generator)

2012

2/7/12:	Salisbury R-IV, Cassville R-IV
2/24/12:	Hollister R-V
3/1/12:	Oak Grove R-VI
3/23/12:	Moniteau County R-V
4/2/12:	Three Rivers College
4/18/12:	Scott City School District
6/13/12:	Crowder College – Webb City
6/27/12:	Delta R-V
8/8/12:	Three Rivers College - Kennett
8/22/12:	Joplin Public School District
8/28/12:	Belton School District #124

10/2/12:	Cabool, Glenwood R-VIII
10/11/12:	Monett R-I
10/29/12:	Nixa R-II
10/30/12:	Christian County, East Prairie R-II, Sarcoxie R-II
11/11/12:	Humansville R-IV, Webb City School District
11/13/12:	Charlack, Marion C Early R-V, City of Monett, Rich Hill School District
12/5/12:	McDonald County R-I, Phelps County R-III, Waynesville R-VI, Ripley County R-IV
12/13/12:	Avilla R-XIII
12/19/12:	Neosho R-V
12/17/12:	City of Amazonia (Generator)

2013

1/15/13:	Doolittle Siren
1/16/13:	Crocker R-II
1/22/13:	Branson Buyout
1/23/13:	Taney County Buyout
1/28/13:	Clearwater R-I
2/8/13:	Eldon R-I, Poplar Bluff R-I
2/26/13:	Iberia
3/6/13:	Cassville R-IV, City of Farmington, Neelyville R-IV
4/10/13:	Greenville R-II, St. John Vianney High School
5/1/13:	Cape Girardeau Siren
6/11/13:	MSSU
6/26/13:	City of Jackson, Andrew County (Boy Scouts), Mid-Buchanan County R-V
7/18/13:	Pinhook Buyout

Adequate and Experienced Staff at Both the State and Regional Level

The Mitigation Section is part of SEMA's Logistics, Resources, Mitigation and Floodplain Management Branch. Permanent full time State hazard mitigation staff consists of two hazard mitigation specialists, one clerical assistant, and the state hazard mitigation officer. In 2007, funding for an additional mitigation position was obtained. This position, a planning specialist, provides technical assistance to local jurisdictions regarding planning issues and mitigation project development. This position is a contract position. The individual currently in this position has attended received FEMA-training on local Hazard Mitigation Planning. In addition, the State uses an area coordinator system for emergency planning. These nine area coordinators have been instrumental in dealing with communities on a one-on-one basis.

The technical skills of all staff members are solid. To ensure consistency and smooth transitions, great care has been taken to ensure that all staff members are cross-trained and receive appropriate FEMA training. The Mitigation Section has directly administered over $100 million in HMA grant funding since 1993. All current staff members have received formal benefit-cost analysis training. Three staff members have taken the FEMA grants management and NEMIS training. All staff members have attended several all-hazard mitigation workshops or state hazard mitigation officer training courses.
Newly hired staff will receive direct training either from existing staff or through partnerships with other state hazard mitigation officers and will attend formal FEMA training as appropriate. See Chapter 6 for further descriptions of staff responsibilities.

State and Regional Relationship

The relationship between the State and FEMA Region VII has always been maintained in an open, professional manner.

Expertise in the Area of Preparing Environmental Documentation and Conducting Benefit-Cost Analyses

SEMA and State agency partners work together to prepare environmental documentation and conduct benefit-cost analyses. This is further proven by the roles of the Department of Natural Resources and the Department of Conservation in providing environmental documentation to ensure compliance with the National Environmental Policy Act. The Department of Natural Resources' State Historic Preservation Officer (SHPO) coordinates with SEMA on all mitigation projects to ensure that any and all historic preservation concerns are recognized and addressed. The Department of Conservation is consulted to ensure compliance with the Endangered Species Act.

Until recently, SEMA performed benefit-cost analyses for all hazard mitigation grant applications. Since the 2004 plan, the RPCs and the local governments have all been offered training on FEMA's BCA software at least once annually and many are now capable of performing the required benefit-cost analysis to be submitted with HMA grant applications. SEMA still provides technical assistance regarding BCAs, but only for communities that do not have the capability to do it themselves. SEMA also reviews all benefit-cost analysis results during the project eligibility time frame.

All current SEMA mitigation staff members have received formal FEMA benefit-cost training and use the software on a regular basis to keep knowledge and skills current.

State Use of the State Hazard Mitigation Planning Team to Prioritize and Select HMGP Applications and Ensure Coordination among Key State Functions

Although a formal organization or arrangement is not always present or used by Missouri to prioritize and select HMGP projects, it is wrong to assume that prioritization of HMGP Projects is carried out in a vacuum. The 1993, 1994, and 1995 buyout projects were selected, coordinated, and managed by a small committee appointed by the governor for this specific purpose. The wisdom in this approach can be found in the results. Six months after funding became available, all projects were approved and one project was completed. Similarly, after flooding in 2008, the Governor called together a steering committee to re-emphasize flooding awareness with a subcommittee comprised of state agencies with resources for flood response and mitigation. For additional description of successful multi-agency coordination, see the description of the "Silver Jackets Program" that followed the 2008 flood event in Section 7.5.1 Mitigation Success . The Silver Jackets Program encourages effective and continuous collaboration between state and federal agencies. This collaboration is critical to successfully reducing the risk of flooding and other natural disasters through coordination where the USACE, SEMA and other agencies have jurisdiction over specific programs. In the State of Missouri, the SRMT serves as an equivalent to the Silver Jackets Program. However, the State has no charter with the Silver Jackets program.

Currently, smaller projects are coordinated with the agencies responsible for environmental approvals, partial funding, or other projects with similar objectives, stakeholders, or locations, such as the Departments of Economic Development, Conservation, Natural Resources, and Transportation; the U.S. Army Corps of Engineers; and others as the situation dictates. This practice will continue with a more formal body used in the event that large project opportunities are presented.

Demonstrated Relationship between the State and Local Governments

Throughout the extensive voluntary buyout program and for all mitigation projects, the State has operated on a basic principle—centralized planning with decentralized execution. To the extent that local governments can manage projects, they are allowed to do so. However, compliance with established procedures, priorities, and "safe guard measures" is required. Local governments have been vocal in their enthusiastic support for this approach. SEMA is routinely told that they provide local governments with exactly what they need to be successful.

Commitment to Training by the State and FEMA

All current SEMA mitigation staff members have received formal benefit-cost analysis training. Three staff members have taken the FEMA grant management and NEMIS training. All staff members have attended several all-hazard mitigation workshops or state hazard mitigation officer training efforts.
Newly hired staff will receive direct training either from existing staff or through partnerships with other state hazard mitigation officers and will attend formal FEMA training as appropriate.

Training for local units of government before and following an HMA award is ongoing. Formality depends on the needs of the community. Currently, SEMA offers annual training on basic mitigation planning, Pre-Disaster Mitigation grant applications, and using FEMA's BCA software. Additional training is offered as new training or software modules are released by FEMA.

The schedule of training that SEMA provided for mitigation planning and HMA grants from 2010 to 2012 is listed below:

Start Day	**Purpose**
2010	
4/1/2010	MACOG Meeting - Plan Updates, Technical Assistance to RPC Directors
5/6/2010	MACOG Meeting - Plan Updates, Technical Assistance to RPC Directors
7/12/2010	BCA Training & App Development Class
9/2/2010	Facilitated MACOG Planners/Mappers workshop and AMEC plan Meeting
9/9/2010	California Enhanced Plan Review Panel Kick-Off
9/27/2010	Coop Plan plan meeting with MACOG, AMEC, RPCs
11/10/2010	Met with NEMO RPC to provide Technical Assistance
12/13/2010	Clayton/Haddington Court Buyout Technical Assistance and Community Meeting
2011	
2/4/2011	Coop Plan meeting with MACOG/AMEC - Technical Assistance
2/7/2011	Met with Meramec RPC to provide technical assistance w/FEMA?
3/3/2011	FEMA Monthly Meeting
6/5/2011	Individual BCA Training to SEMO RPC
6/27/2011	Local Mitigation Plan Review Tool Pilot - Webinar
7/7/2011	MACOG Meeting - Plan Updates, Technical Assistance to RPC Directors
7/18/2011	Presented Mitigation Planning Class at Pioneer Trails RPC w/FEMA
7/19/2011	Provided Feedback on Plan Review Tool Draft to FEMA

7/27/2011	Presented Mitigation Planning Class at SEMO RPC w/FEMA
8/2/2011	BCA Training & App Development Class
8/9/2011	Presented Mitigation Planning Class at SCOCOG w/FEMA
2/1/2012	HMGP Safe Room Application Training FEMA/SEMA

2012

2/2/2012	MACOG Meeting - Plan Updates, Technical Assistance to RPC Directors
3/10/2012	Presented Mitigation Planning Training at MACOG Meeting in JC
5/20/2012	ASFPM Conference in San Antonio, TX
6/6/2012	BCA Webinar (DFA Module) Provided by FEMA
8/11/2012	Presented Mitigation Planning Class at Mid-MO RPC
9/20/2012	Application Assistance/Tech Assistance to MoDNR-State Parks & OA FMDC
9/24/2012	Individual BCA Training to MoDNR - State Parks
12/10/2012	BCA & App development training to MoDNR - State Parks

7.4 Assessment of Mitigation Actions

Requirement §201.5(b)(2) (iv):	The enhanced plan must document the system and strategy by which the state will conduct an assessment of the completed mitigation actions and include a record of the effectiveness (actual cost avoidance) of each mitigation action.

This section explains how the State assesses the effectiveness of mitigation projects, both pre- and post-disaster. Also explained is how SEMA has improved their ability to monitor and track each completed project and potential losses avoided since development of the original plan in 2004.

7.4.1 Annual Progress Assessment/Review of Mitigation Goals, Objectives, and Measures

In order for any program to remain effective, the goals and objectives of that program must be reviewed periodically. The Missouri State Hazard Mitigation Plan is reviewed annually. This provides the simplest, direct and ongoing methodology for assessing and reviewing mitigation goals, objectives, and actions. At a minimum, the review addresses the following issues:

- Are the established goals and objectives realistic? (Take into consideration available funding, staffing, and state/local capabilities, and the overall state mitigation strategy.)
- Has the State clearly explained the overall mitigation strategy to local governments?
- Are proposed mitigation projects evaluated based on how they help the State and/or local government meet their overall mitigation goals and objectives?
- How have approved mitigation projects complemented existing State and/or local government mitigation goals and objectives?
- Have completed mitigation projects generated the anticipated cost avoidance or other disaster reduction result?

For the 2013 update, the SHMPT reconsidered the validity of the goals and objectives of this mitigation plan and of the State mitigation program. This is detailed in Section 4.1 Hazard Mitigation Goals and Objectives. The SHMPT decided to maintain the current goals and objectives as they are considered to remain valid and applicable in guiding the mitigation strategy of the State.

The overall mitigation strategy is clearly communicated to local governments throughout the year and is an ongoing process. The strategy is explained through SEMA mitigation training and workshops (BCA, HMA, mitigation planning) and at annual meetings of the Missouri Emergency Preparedness Association, the Missouri Floodplain and Stormwater Managers Association, and the Missouri Association of Councils of Governments.

In order to earn SEMA approval, mitigation projects must complement the overall mitigation strategy of the State as well as the applicable local government. This is included in the list of questions to help guide the distribution of mitigation project funds detailed in Section 5.3.2 Project Grants.

How SEMA determines whether or not completed mitigation projects generate the anticipated loss avoidance or other disaster reduction result is explained in Section 7.4.2 Post-disaster Progress Assessment/Review for Mitigation Goals, Objectives, and Measures.

Finally, the Logistics, Resources, Mitigation, and Floodplain Management Branch of SEMA furthers this programmatic progress assessment through the ongoing tracking of:

- Mitigation activities during the past year
- Mitigation grants in progress, including
  - Affected jurisdiction
  - Brief description of the project
  - Project cost
  - Source of funding
  - Summary of project status (percent complete)
- Executed mitigation grant support contracts
- Floodplain management activities during the past year, including
  - NFIP statewide statistics
  - NFIP training activities conducted

All of the above information is captured in SEMA's fiscal year annual report.

It may be difficult to determine the actual loss avoidance and effectiveness of many mitigation projects during project development. Initially, the potential impact of mitigation projects and initiatives can only be estimated. However, based on past experience with similar projects, SEMA can make an educated determination as to the potential for success of the proposed mitigation project.

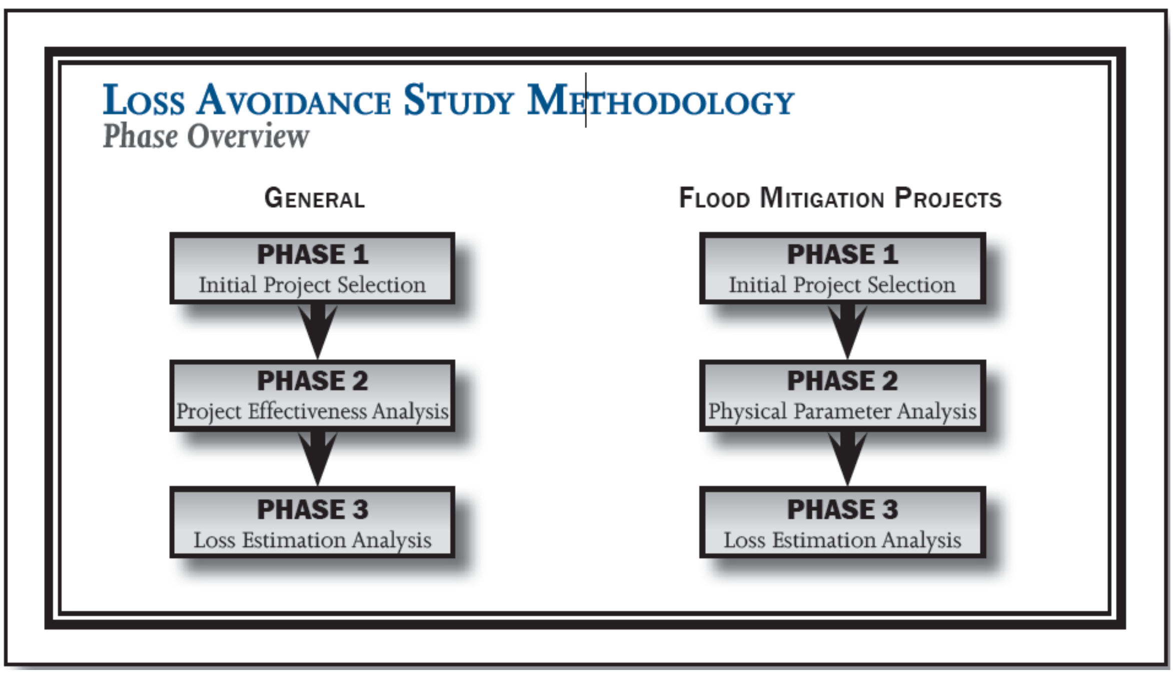
Based on the results of this information and the annual review, the State considers making adjustments to its goals, objectives, and actions to meet the current and future mitigation needs of the State and its local governments.

7.4.2 Post-disaster Progress Assessment/Review of Mitigation Goals, Objectives, and Measures

Every year, Federal, State, and local agencies, as well as private entities, contribute funding to mitigation projects that will reduce or eliminate the long-term risks posed to people, the built environment, and the economy by natural hazards. The Federal Emergency Management Agency (FEMA) awards mitigation grants on the basis of whether the proposed mitigation projects are cost-effective.

Following a hazard event, SEMA mitigation staff query local officials to document how mitigation actions instituted in the affected areas reduced the amount of damage or loss of life that could have resulted from an event. SEMA has updated this query process and formalized loss avoidance documentation through a web-based tool which follows the recent loss avoidance methodology developed by FEMA. FEMA developed the loss avoidance methodology to evaluate the effectiveness of mitigation projects based on the analysis of actual events. This methodology can be applied to the mitigation of any type of natural hazard. Losses avoided are determined by comparing the damage that would likely have been caused by the same storms without the project (Mitigation Project Absent, MP_A) with damage that actually occurred with the project in place (Mitigation Project Complete, MP_C). Figure 7.4.2.1 and Figure 7.4.2.2 shows the three phases of the general methodology for loss avoidance studies:

Figure 7.4.2.1 – Loss Avoidance – Phase Overview

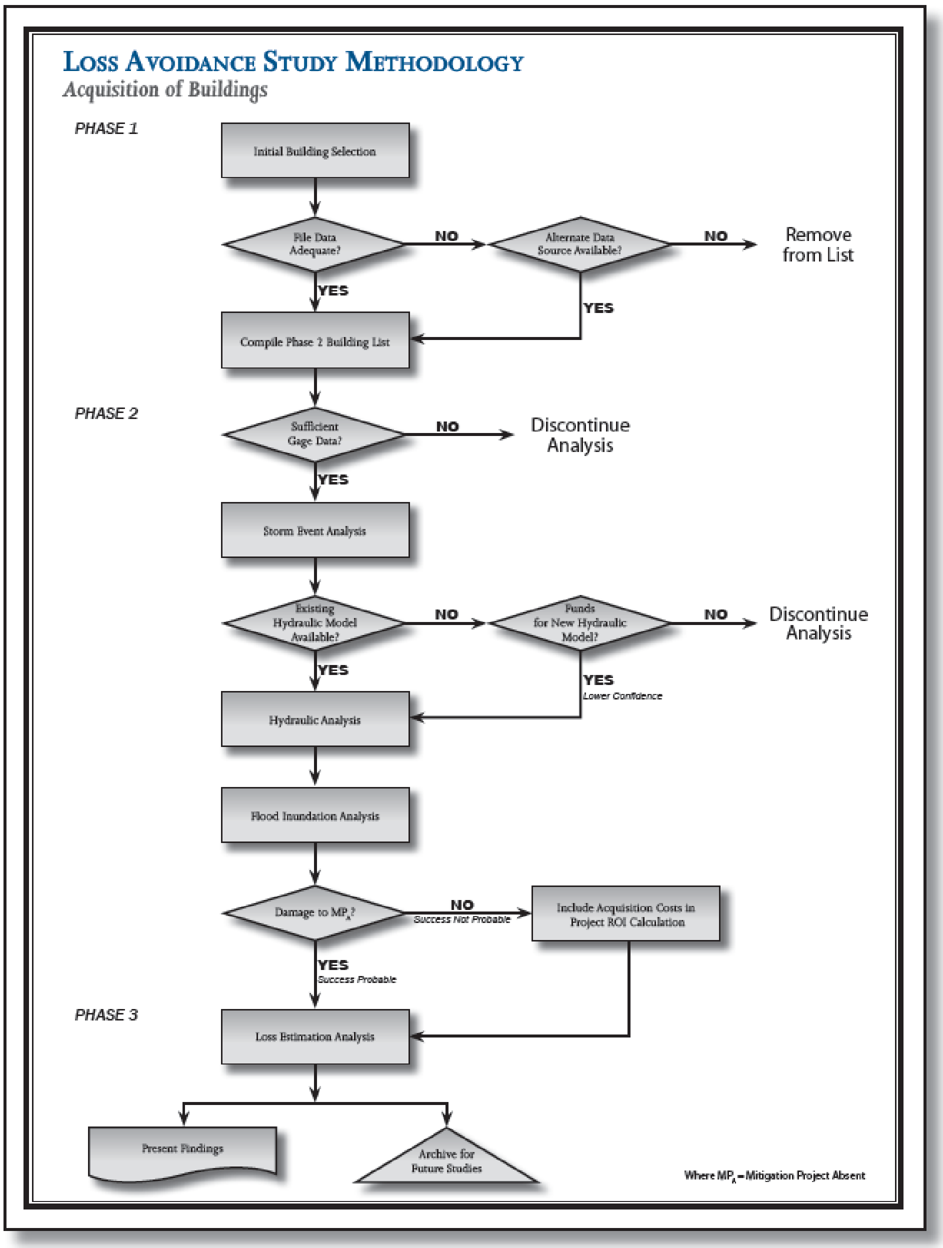


Phase 1 focuses on the selection of the completed project area to be included in the loss avoidance study. Structures are screened based on the availability of data required for completion of the study. This includes actual project costs, construction completion dates, first floor elevations, structure location information, and structure information, including the type, basement information, number of floors, square footage, and building replacement value. Structures with adequate data advance to Phase 2.

Phase 2 includes a storm event analysis, to determine whether a post-construction storm event is severe enough to have caused damage if the project had not been completed (MP_A scenario), and a hazard analysis, to determine the impact of the hazard event (e.g., depth of flooding) at the mitigation project location.

Phase 3 includes two steps. First, an economic evaluation of the project scope is completed for both the MP_A and MP_C scenarios for each hazard event analyzed. The difference between the total losses for the two scenarios is calculated and losses avoided are determined. Second, the return on investment (ROI) is assessed by comparing the losses avoided to the total project investment.

Figure 7.4.2.2 – Loss Avoidance – Building Acquisition



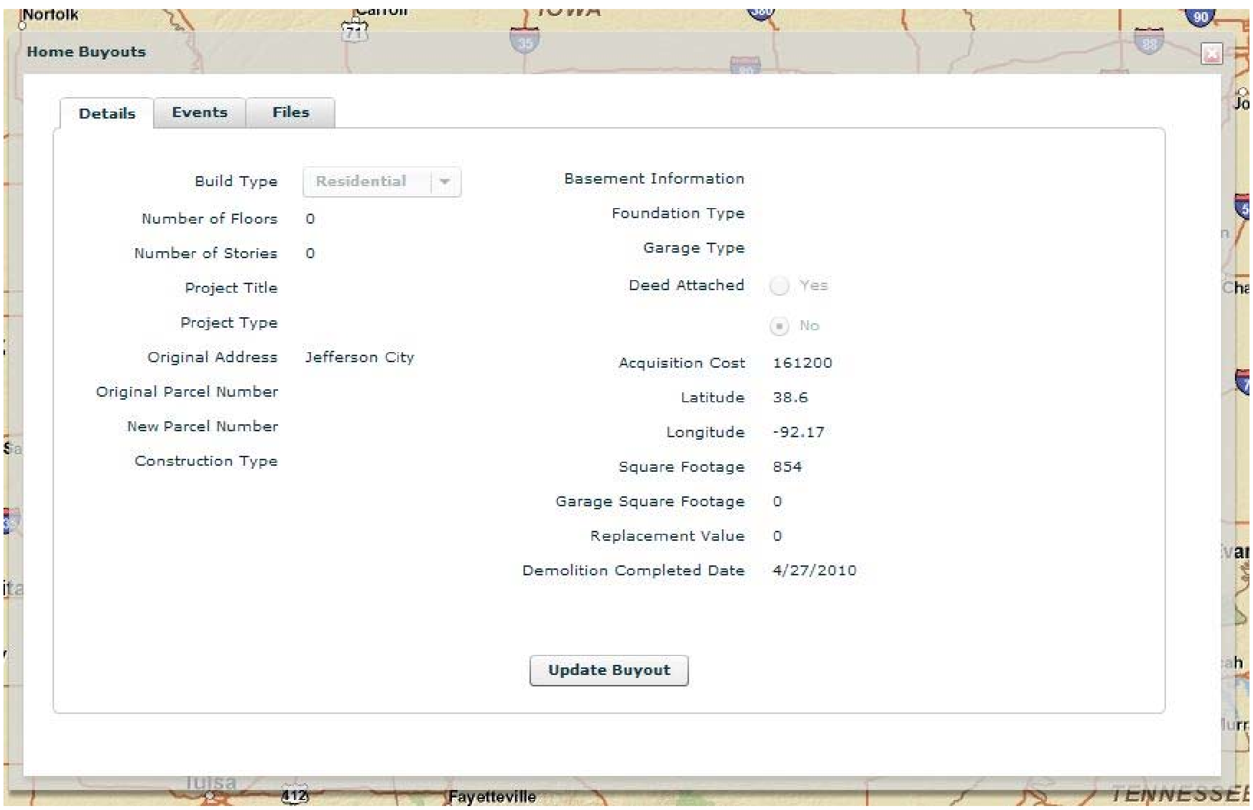
SEMA has developed a web-based, loss avoidance tool (LAT) to assist SEMA staff and local officials collect and store the data necessary to complete a loss avoidance study following a hazard event.

Web-Based, Loss Avoidance Tool (LAT)

The web-based, loss avoidance tool (LAT) is a database of the structural data necessary to complete Phase 1 of a loss avoidance study and is a data collection tool for the storm event data necessary to complete Phase 2 of a loss avoidance study. The LAT can be accessed here.

1. Initial Project Selection – For all completed mitigation projects within the State, the LAT database has been populated with project details as included in the approved grant application and project closeout documents. This includes actual project costs, construction completion dates, first floor elevations, and structure information. Figure 7.4.2.3 displays the structural data form for a residential acquisition project.

Figure 7.4.2.3 – Residential Acquisition Structure Data Form



Each mitigation project has also been spatially located based upon the street address or latitude/longitude, as either obtained from the project grant application or field located with GPS. Efforts to map completed buyouts prior to 2002 have proven difficult because communities have combined parcels and lots into combined open spaces, streets and addresses no longer

exist (as a result of the buyouts), and legal property descriptions are not accurate enough to pinpoint precise locations.

Those mitigation projects with limited structural or location data are included in the LAT database, but will not move forward to Phase 2 and be utilized in a loss avoidance study.

The LAT database may be updated at any time to include additional project information. For future mitigation projects, the structure data necessary to complete Phase 1 of a loss avoidance study will be entered by SEMA staff upon project completion and closeout.

2. Project Effectiveness Analysis – Because a loss avoidance study measures benefits of a completed project based upon an actual event, the local official will be tasked with completing the storm event data collection form following a hazard event within their community. The local official will spatially select those mitigation projects within the hazard event area and complete the appropriate loss avoidance data collection forms. Figure 7.4.2.4 presents an example of the mitigation project location. The LAT currently contains storm event forms for community safe rooms and residential buyout projects. See Figure 7.4.2.5 and Figure 7.4.2.6, respectively. As the LAT is further developed, the local official will receive an email prompt to visit the SEMA website and LAT following the activation of a local emergency operation center.

Figure 7.4.2.4 – Example of Mitigation Project Location

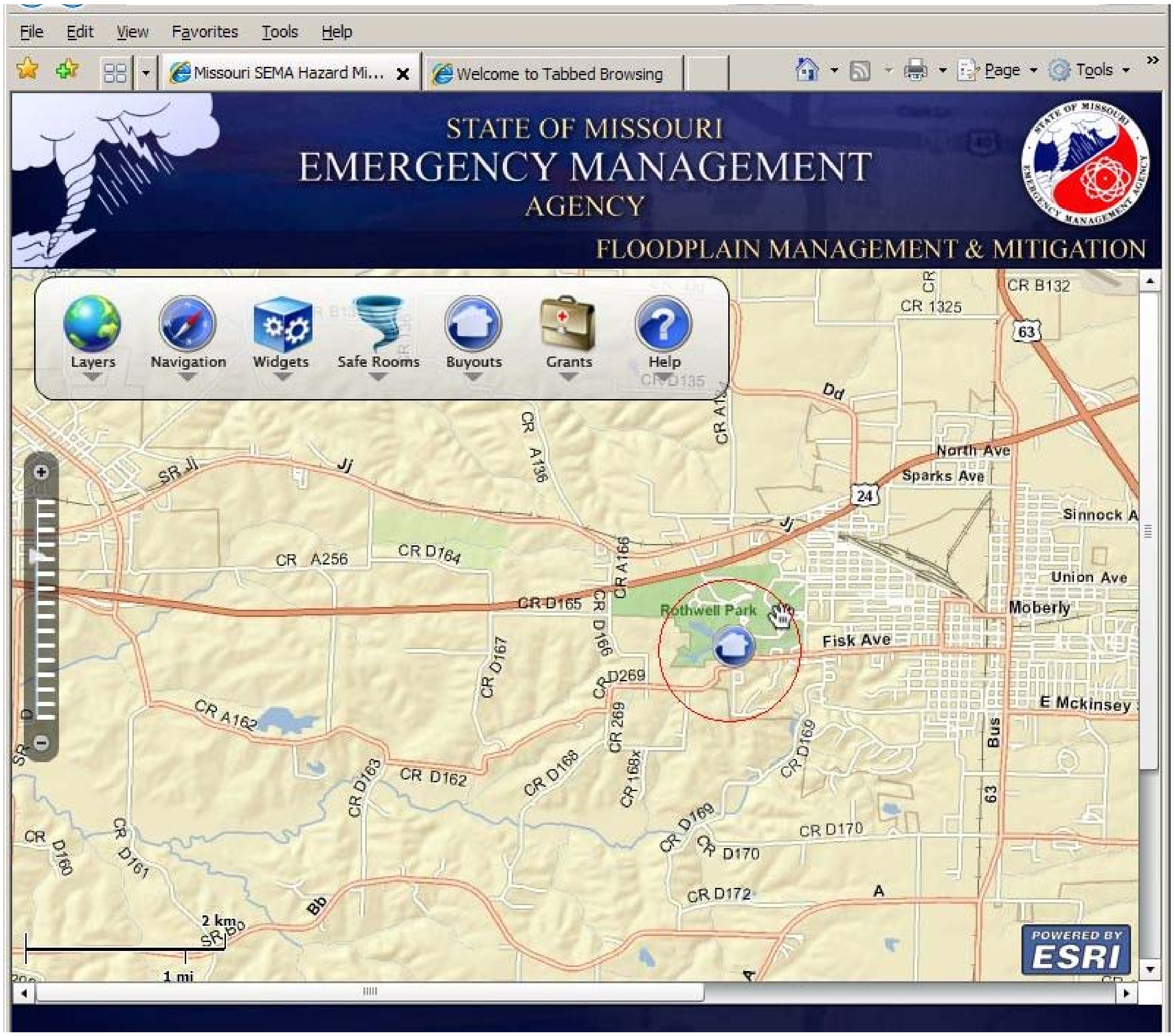


Figure 7.4.2.5 – Post-Event Community Safe Room Form

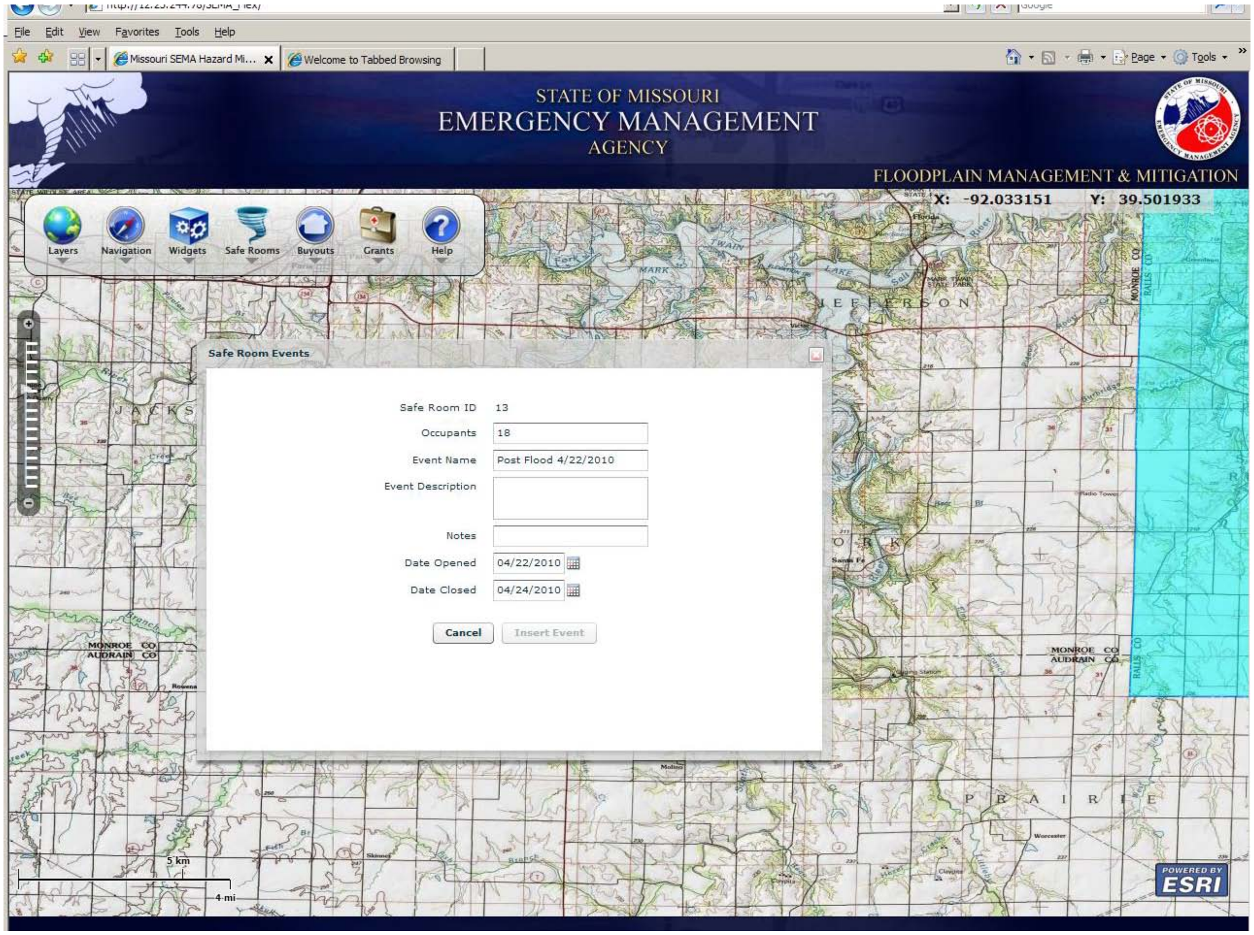
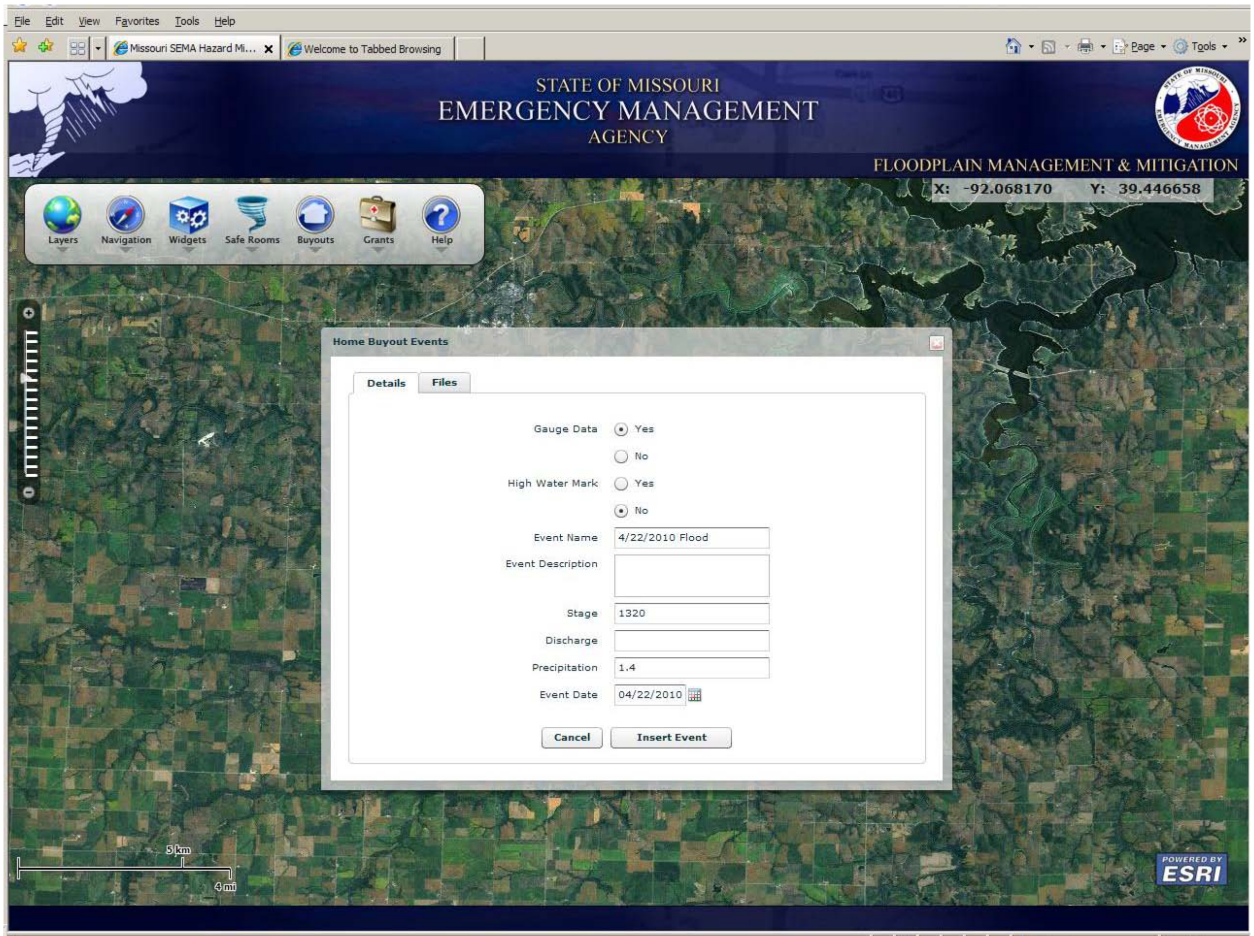


Figure 7.4.2.6 – Post-Event Residential Buyout Form



By tasking the local official with completing the storm event forms, SEMA will be able to continually track mitigation projects that have been impacted by a disaster and are ready to move forward to Phase 3 of a loss avoidance study.

3. Loss Estimation Analysis - This final phase consists of estimating losses avoided based on the effectiveness of the mitigation project during the MP_C storm events. The two major tasks in Phase 3 are (1) calculating losses avoided and (2) calculating the return on investment. These tasks are not currently included as an automated process within the LAT. SEMA staff will complete the tasks of Phase 3 outside of the LAT environment.

   Local officials will continue to be encouraged to contact SEMA whenever a project successfully reduced losses from a hazard event. This information and the results of completed loss avoidance studies will be incorporated into mitigation success stories to aid in the assessment of the current and future goals, objectives, and actions.

Completed Loss Avoidance Studies

Prior to the development of the new LAT described above, and to demonstrate the success of the buyout programs that occurred after the flooding in 1993, 1994, and 1995, SEMA published the

acquisition success story in *Stemming the Tide of Flood Losses*. This loss avoidance study demonstrated the effectiveness of the buyout program in 22 Missouri communities.

Since the 2010 update, 4 presidential and emergency disaster declarations have been issued for Missouri (See Table 7.4.2a).

Table 7.4.2a Major Disaster and Emergency Declarations in Missouri since 2007 Plan

Declaration Date	Disaster No.	Incident Type
June 11, 2007	DR 1708	Severe Storms and Flooding
September 21, 2007	DR 1728	Severe Storms and Flooding
December 12, 2007	EM 3281	Severe Winter Storms
December 27, 2007	DR 1736	Severe Winter Storms
February 5, 2008	DR 1742	Severe Storms, Tornadoes, and Flooding
March 12, 2008	DR 1748	Severe Winter Storms and Flooding
March 19, 2008	DR 1749	Severe Storms and Flooding
May 23, 2008	DR 1760	Severe Storms and Tornadoes
June 25, 2008	DR 1773	Severe Storms and Flooding
November 12, 2008	DR 1809	Severe Storms, Flooding, and a Tornado
January 30, 2009	EM 3303	Severe Winter Storms
February 17, 2009	DR 1822	Severe Winter Storms
June 19, 2009	DR 1847	Severe Storms, Tornadoes, and Flooding
July 31, 2010	DR 1934	Severe Storms, Flooding, and Tornadoes
January 31, 2011	DR 1961	Severe Winter Storm, and Tornadoes
April 19, 2011	DR 1980	Severe Storms, Tornadoes, and Flooding
June 1, 2011	DR 4012	Flooding

Source: Federal Emergency Management Agency

Following the spring and summer floods of 2008 (DR-1749 and DR-1773), FEMA partnered with the State of Missouri to complete a Loss Avoidance Study to assess the effectiveness of the acquisition/demolition projects in eastern Missouri along the Mississippi River and its tributaries. The report "*Loss Avoidance Study: Eastern Missouri, Building Acquisition Part One: General Overview and Part Two: Detailed Methodology*" provides detailed documentation of the methodology implemented and results.
For this study, FEMA employed the loss avoidance methodology, as previously described:

1) Initial Project Selection – The initial project list covered eight counties, nine communities, 20 residential acquisition projects, and 2,049 properties. The properties included 1,091 residential buildings and 958 vacant lots. The communities were located in eastern Missouri and include the Cities of Arnold, La Grange, Cape Girardeau, St. Charles, Hannibal, Winfield, Piedmont, and Marble Hill, and the County of St. Charles. Data collection efforts for the projects resulted in the elimination of several buildings from the study due to the lack of flood impact from the 2008 storm events, the lack of available structure location data, and incomplete acquisition/demolition activities. A total of

885 buildings proceeded to Phase 2 of the loss avoidance study. The vacant lots, which were acquired to create continuous open space areas, were not analyzed in Phase 2, but were included in the final return on investment computations as a project cost.

2) Project Effectiveness Analysis – For this loss avoidance study, a flood inundation analysis was conducted. The flood depth that would have occurred inside each building, had the building not been acquired, was calculated. Flood depths were calculated using both stream gage stage data and discharge data.

   Cross sections from the Flood Insurance Studies (FIS) for the project area were digitized in a GIS environment. Stream gage stage data was input at the cross section corresponding to the gage location, and it was noted which recurrence intervals the stage fell between using the FIS or USACE flood profiles. Water surface elevations (WSEs) at the remaining cross sections along the stream profile were then interpolated through hand calculations using the appropriate recurrence intervals as lower and upper bounds. The water surface elevations were input into GIS and converted to a water surface layer.

   Where stream gage data was not available, discharge data was used. The lower and upper bounding recurrence intervals were determined from the discharge tables within the FIS reports. The elevation corresponding to the recurrence interval was found on the FIS flood profile for each cross section, and a water surface layer was created.

   Once flood surfaces were digitally created for the 2008 storm events affecting the communities, the flood depth at each building location (measured from the WSE to the ground) was extracted and exported in table format. Ground-surface elevations were derived from USGS digital elevation models (DEMs). The flood depth *inside* each building was then determined by adjusting the flood depth based on the first floor elevation.

3) Loss Estimation Analysis – As previously noted, all buildings included in the study are residential structures. Therefore, the loss estimation analysis included physical damage (building and contents) and loss of function (displacement expense and disruption of residents). Loss of business income, lost wages, and loss of public service damages were not calculated.

   Physical damages to the buildings and contents were based upon the flood depths determined in Phase 2 and computed using FEMA's Benefit Cost Analysis (BCA) Version 4 software, the U.S. Army Corps of Engineer's generic building damage curves, and the Federal Insurance Administration mobile home damage curves.

   Displacement cost was estimated based upon the repair time and utilized default values for one-time displacement and monthly rental costs. For disruption, FEMA BCA Version 4 software guidance provides a national average wage. The time of disruption was calculated using the estimate that each adult occupant is disrupted 40 hours plus 8 hours for every 1% of building damage.

   The losses avoided for the spring and summer 2008 events were calculated for each individual building. The cumulative amount of losses avoided was then calculated for both the Mitigation Project Absent (MPA) and Mitigation Project Complete (MPC) scenarios. The total losses in the MPC scenario were then subtracted from the total losses in the MPA scenario to determine the total

losses avoided. It should be noted, no losses were calculated for the MPC scenario because the buildings no longer existed and thus no damages could be incurred. The total losses avoided for the communities were valued at $93.6 million.

Calculating the return on investment (ROI) is the final task of Phase 3. The ROI is calculated by dividing the losses avoided by the total investment for the project made by all parties involved. For this study, the project cost was valued at $44.2 million, resulting in a return on investment of 21.2 percent. Table 7.4.2b presents the lost estimation results.

Table 7.4.2b Eastern Missouri Loss Avoidance Study Results

AGGREGATE RETURN ON MITIGATION INVESTMENT

Analysis Information			Results by Loss Category				Total Losses Avoided	Project Investment	Project ROI	Community ROI
Community	Disaster, Project Number, and Event	Number of Buildings Included in Analysis	Building Damage	Contents Damage	Displacement Cost	Disruption Cost				
Arnold	985-0002 (spring)	79	$3,175,228	$2,878,203	$724,398	$880,433	$8,010,297	$7,054,582	85%	77%
	FMA-PJ-07MO-1997002 (spring)	1	$48,198	$26,934	$6,910	$12,205	$94,248	$104,435	90%	
	FMA-PJ-07MO-1998002 (spring)	3	$48,890	$29,378	$2,411	$15,752	$96,430	$328,901	29%	
	FMA-PJ-07MO-1999001 (spring)	6	$25,506	$18,603	$0	$10,171	$54,280	$675,985	8%	
La Grange	985-0027 (summer)	11	$481,105	$298,942	$124,431	$447,850	$1,265,024	$243,811	519%	519%
Cape Girardeau	1054-0001 (spring)	79	$380,568	$238,370	$34,488	$190,280	$843,708	$2,803,431	30%	49%
	1054-0001 (summer)	79	$871,884	$547,830	$131,178	$453,818	$1,930,844	$2,803,431	69%	
	1403-0004 (spring)	2	$0	$0	$0	$0	$0	$60,629	0%	
	1403-0004 (summer)	2	$1,038	$994	$0	$2,832	$4,863	$60,629	8%	
St. Charles County	985-0001 (summer)	467	$27,969,023	$19,899,004	$8,028,505	$8,911,969	$55,752,634	$22,572,245	247%	247%
City of St. Charles	985-0027 (summer)	8	$0	$0	$0	$0	$0	$423,247	0%	
Hannibal	985-0004 (summer)	80	$6,704,530	$5,898,533	$1,677,824	$2,224,599	$13,314,238	$2,220,253	600%	600%
Winfield	985-0015 (summer)	49	$2,984,396	$2,349,148	$838,307	$1,338,120	$8,215,974	$1,387,803	448%	448%
Piedmont	985-0045 (spring)	15	$796,451	$608,444	$175,855	$600,524	$1,896,898	$387,547	487%	304%
	1006-0007 (spring)	18	$781,186	$577,325	$181,006	$487,771	$1,817,425	$724,121	251%	
	1023-0005 (spring)	2	$190,473	$155,464	$42,812	$84,007	$371,325	$47,708	778%	
	1054-0008 (spring)	10	$474,838	$358,478	$107,885	$245,035	$1,039,470	$448,518	233%	
	1403-0008 (spring)	10	$195,866	$113,477	$33,684	$138,653	$481,680	$490,375	98%	
	FMA-PJ-07MO-1997003 (spring)	10	$834,854	$739,297	$185,758	$420,862	$1,740,581	$365,773	476%	
	FMA-PJ-07MO-1998003 (spring)	6	$320,542	$268,988	$74,559	$193,162	$718,302	$189,425	378%	
Marble Hill	1403-0011 (spring)	28	$0	$0	$0	$0	$0	$782,707	0%	0%
		TOTAL	$45,974,342	$34,969,291	$10,179,708	$16,836,259	$93,636,111	$44,153,436		212%

Source: FEMA Loss Avoidance Study: Eastern Missouri, Building Acquisition Part Two: Detailed Methodology, page 5-19.

SEMA continues to provide success stories to FEMA and to organizations like the Association of State Floodplain Managers to educate the public about the effectiveness of mitigation.

7.5 Effective Use of Available Mitigation Funding

Requirement §201.5(b)(3):	The enhanced plan must demonstrate that the state effectively uses existing mitigation programs to achieve its mitigation goals.

This section identifies some general and specific hazard mitigation projects. They are examples of the types of projects that have made, and continue to make, Missouri's hazard mitigation program effective and successful. These projects, and others like them, have been approved in the past based on their ability to achieve some, or all, of the State's mitigation goals and objectives. Because of this demonstrated success, similar projects are likely to be approved in the future.

As a result of the successes achieved through past and present mitigation funding sources and through public-private partnerships, SEMA remains committed to continuing its efforts to encourage leveraging available funds and establishing partnerships for project leadership, implementation, and maintenance. The following tables (Table 7.5a and Table 7.5b) from Section 4.4 Mitigation Actions reiterate the effectiveness of actions funded through SEMA and how they relate to the State's mitigation goals and the Emergency Management Accreditation Program's (EMAP) mitigation standards. Information on specific EMAP standards can be found at http://www.emaponline.org/index.php?option=com_content&view=article&id=118&Itemid=110. All of the mitigation actions, based on past experience, can impact public safety in varying degrees of effectiveness. Effectiveness can be expressed as high, medium, or low according to the ability of the action to mitigate the hazard impacts to life, property, or both.

- **Life**— the action mitigates hazard impacts to life safety,
- **Property**— the action mitigates hazard impacts to property,
- **Both** – the action mitigate hazard impacts to both life and property.

Table 7.5a Missouri Mitigation Action Categories Strategy Overview

Action Category	Priority	Responsible Agency for Implementation	Hazards Addressed	Link to Local Plans, Actions, and Assistance	Protected by the Action	EMAP Mitigation Considerations
M1—State and Local Hazard Mitigation Plans	High	SEMA/RPCs/ local jurisdictions	All	Continued use of RPCs	Both	1,2,3,4,5,6,7,89,10,11,12
M2—NFIP Floodplain Management and Community Rating System	High	SEMA/local jurisdictions	Flood	Community assistance visits, workshops	Both	1,2,3,4,5,6, 7,8,9,12

Action Category	Priority	Responsible Agency for Implementation	Hazards Addressed	Link to Local Plans, Actions, and Assistance	Protected by the Action	EMAP Mitigation Considerations
M3—Voluntary Property Acquisitions (Flood Buyout)	High	SEMA/local jurisdictions	Flood	Projects identified in local plans	Both	2,3,6
M4—Voluntary Elevation, Relocation, Floodproofing	High	SEMA/local jurisdictions	Flood	Projects identified in local plans	Both	1,2,3,6,9
M5—Tornado Safe rooms	High	SEMA/local jurisdictions	Tornado	Projects identified in local plans	Life	1,3,6,9
M6—Earthquake/High Wind Structural Mitigation Projects	Medium	SEMA/MoDOT	Earthquake Tornado	Projects identified in local plans	Life	1,3,9
M7—Earthquake/High Wind Nonstructural Mitigation Projects	Medium	SEMA/local jurisdictions	Earthquake Tornado	Projects identified in local plans	Both	1,3,9
M8—Structural/ Infrastructure Mitigation Projects (including Public Assistance projects)	Medium	SEMA/MoDOT/ local jurisdictions	Flood	Projects identified in local plans	Both	1,2,3,5,6,7,8,9,11
M9—Buried Electric Service Lines	Low	Local jurisdictions/ certain utility providers	Multiple	Projects identified in local plans	Both	3,4,6,9
M10—State 5% Initiative Projects	Low	SEMA/local jurisdictions	Multiple	Projects identified in local plans, difficult to measure cost-effectiveness	Both	1,5,6,10,11,12
M11—Technical Assistance	Low	SEMA and other agencies	Multiple	Needs identified in local plan capability assessments	Both	1,2,3,4,5,6,7,89,10,11,12

Note:
*High denotes action mitigates impacts to life safety and property, moderate denotes action mitigates impacts to life safety only or property only

Table 7.5b Mitigation Action Categories and Goals Crosswalk

Objectives	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11
Goal 1: Improve the Protection of Human Life, Health, and Safety											
Objective 1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 3	✓	✓			✓	✓	✓			✓	✓
Objective 4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 5	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Goal 2: Improve the Protection of Continuity of Government and Essential Services Safety											
Objective 1	✓	✓			✓	✓	✓	✓	✓	✓	✓
Objective 2	✓	✓			✓	✓	✓	✓	✓	✓	✓
Objective 3	✓	✓			✓	✓	✓	✓	✓	✓	✓
Objective 4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 5	✓	✓			✓	✓	✓	✓	✓	✓	✓
Goal 3: Improve the Protection of Public and Private Property											
Objective 1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 3	✓	✓			✓	✓	✓			✓	✓
Objective 4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 5	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Goal 4: Improve the Protection of Community Tranquility											
Objective 1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 3	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Objective 5	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Table 7.5c provides specific types and numbers of projects and funding amounts from 2002-2013. For reference, the corresponding Mitigation Action Category is also provided. For additional details on funding by year, see Section 4.4.5.

Table 7.5c Summary of Mitigation Actions, 2002–2013

Project Type	Action Category	Number of Projects	Estimated Funding Amount
State and Local Hazard Mitigation Plans	M1	258	$7,885,551
Flood Buyouts	M3	67	$47,337,218

Project Type	Action Category	Number of Projects	Estimated Funding Amount
Flood Elevations	M4	3	$488,573
Tornado Safe Rooms	M5	133	$159,925,978
Tornado Safe Rooms - Multipurpose	M5	1	$686,493
Bridge Replacements	M8	1	$449,787
Low Water Crossings	M8	8	$888,246
Streambank Stabilizations	M8	2	$92,267
Basin	M8	1	$1,333,333
Culvert	M8	2	$553,625
Water Supply Interconnects	M8	1	$66,701
Buried Electric Lines	M9	10	$11,959,530
State 5% Initiative Projects	M10	12	$1753,,866

Table 7.5.C provides documentation of the State's ability to make use of funding available from FEMA HMA grant programs to implement the State's mitigation strategy. There have been instances in the past when the total amount for HMA grants could not be fully obligated. In all instances, the State forwarded applications and supplements to exhaust all available funding options. However, due to circumstances beyond the State's control, such as project cost underruns, loss of local match, local withdrawal of projects, or decrease in scope due to the voluntary nature of some projects, funds could not be fully obligated. In these instances, the availability of funds was not known until after the application periods had expired. Therefore, the State was not at liberty to forward additional applications to make use of any remaining funds.

It should be noted that the State has successfully closed out multiple grants in the previous years. These include five separate HMGP post disaster awards, three PDM grants, two LPDM grants, and one FMA and RFC grant. Also, the State has successfully obligated all HMGP funding that has been awarded from 2010 to 2013.

The following activities illustrate the types of projects that have been approved as part of the State's mitigation program. This list is not all-inclusive; however, it does demonstrate the effective use of available mitigation funding and how SEMA has used FEMA and non-FEMA funding to support mitigation in Missouri.

Local Hazard Mitigation Plan Development (M1)

As of April 2013, 79 of 114 Missouri counties had FEMA-approved hazard mitigation plans. Included in this number are 6 counties that are in the process of updating their current plan. Another 33 counties are in the process of updating their expired plans. This leaves only two counties in the State that have not initiated the planning process. Altogether, 94% of Missouri's population is covered by a local hazard mitigation plan.

Mitigation funds have been used to help communities throughout the State develop hazard mitigation plans. As part of this process, these communities have developed public-private partnerships that have expanded their work into other mitigation-related activities. As a result of planning activities,

communities are now more aware of the benefits of an active mitigation program and have instituted mitigation projects with their own funds.

The local mitigation planning project supports all of the goals of this plan by contributing to the development of local plans that complement the State plan and serving as the foundation for FEMA HMA grant eligibility (see Table 7.5b and Table 7.5c). Historically, local hazard mitigation plans in Missouri have been funded through the Hazard Mitigation Grant Program and the Pre-Disaster Mitigation program with local matching funds and/or in-kind services.

Preparation/Updating of Floodplain Maps (M2 and M11)
Funds from a variety of programs have been used to develop flood maps for previously unmapped areas and to revise/update older existing maps. This initiative will enable more communities in the State to join the National Flood Insurance Program (NFIP). As a result, more individuals, families, and businesses will be able to get insurance to cover future flood-related losses. In Missouri, SEMA is participating in FEMA's Risk MAP program and as of early 2013, 74 counties have effective, county-wide updated Flood Insurance Rate Maps (FIRMs); 5 counties have preliminary county-wide FIRMs; and 3 counties are in the FIRM development process.

The Missouri Risk MAP effort supports all of the goals and objectives of this plan as indicated in Table 7.5b and Table 7.5c. The program also supports the State's mitigation strategy for ensuring continued effective use of resources by demonstrating how partnerships with other State and local agencies are used to leverage funding. In Missouri, three cities, two counties, and SEMA participate in FEMA's Cooperating Technical Partners (CTP) Program. CTP partnerships are established with NFIP participants that have both the interest and capability to become more active in the FEMA flood hazard mapping program by collaborating to maintain up-to-date flood hazard maps and other flood hazard information.

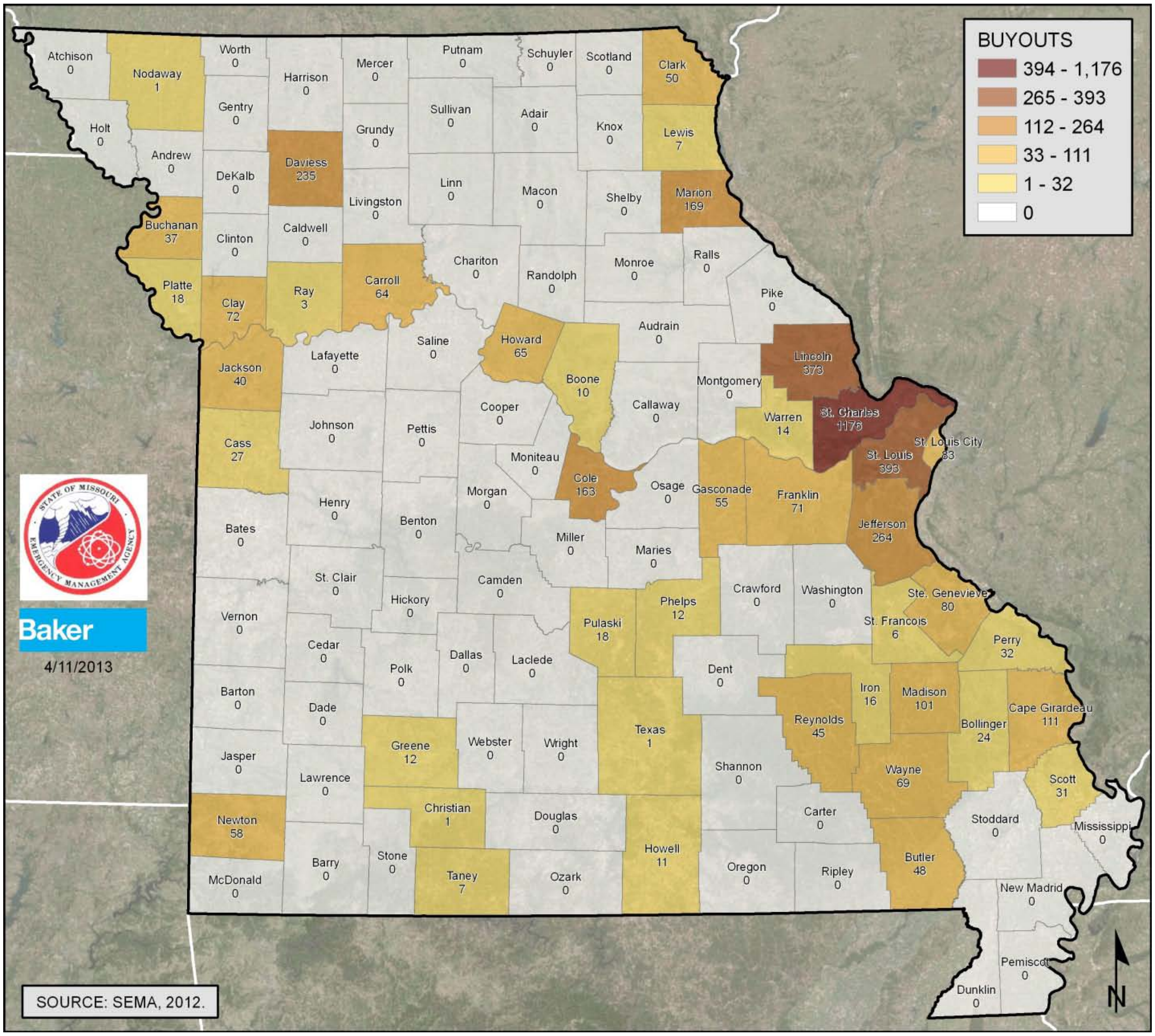
Acquisition of Primary Residences in Flood-Prone Areas (M3 & M4)
The State has previously, and most likely will continue to, make the acquisition of primary residences in flood-prone areas a top priority. Hazard Mitigation Grant Program funds from previous Missouri disasters have been used to fund this extremely successful program. The Missouri Community Buyout Program was recognized as a model for the nation following the devastating 1993 floods.

This program removed families and insurable buildings from harm's way. By doing so, it eliminated the threat of flooding and the associated financial and emotional hardship on those families that participated in the program; reduced the cost of future disasters to the federal, state, and local government; and provided the participating community with open space to develop parks for the entire community to enjoy. It also has reduced impacts on local first responders, who have fewer life safety emergencies to handle during floods.

Since the 1993 flood, this buyout program has continued to demonstrate how Missouri has effectively used available mitigation funding programs and packaged these mitigation funds with funds from non-FEMA sources. The document *Past Mitigation Projects* illustrates that mitigation funds have come from FEMA's Hazard Mitigation Grant Program, Flood Mitigation Assistance Program, Repetitive Flood Claims Program, Severe Repetitive Loss Program and the Pre-Disaster Mitigation program over multiple annual budgets and have stemmed from multiple disasters.

The FEMA funds have been matched, as appropriate, with Community Development Block Grants (including supplemental appropriations for Unmet Needs), State general revenue, and local government funds. The buyout program supports the goals and objectives of this plan as indicated in Table 7.5b and Table 7.5c. The program also supports the State's mitigation strategy for ensuring continued effective use of resources by demonstrating how partnerships with other State and local agencies can be used to leverage funding. Figure 7.5.1 shows the range of total buyouts per county by 2013.

Figure 7.5.1 - Total Number of Buyouts Per County as of May 2013



Acquisition of Severe Repetitive Loss Properties (M3)

In Missouri, there are also 194 severe repetitive loss properties as of April 2013. 25 of those properties have been mitigated since the 2010 update as shown in Figure 7.5.2.

Figure 7.5.2 - Total Number of Mitigated SRL Properties Per County Since 2010

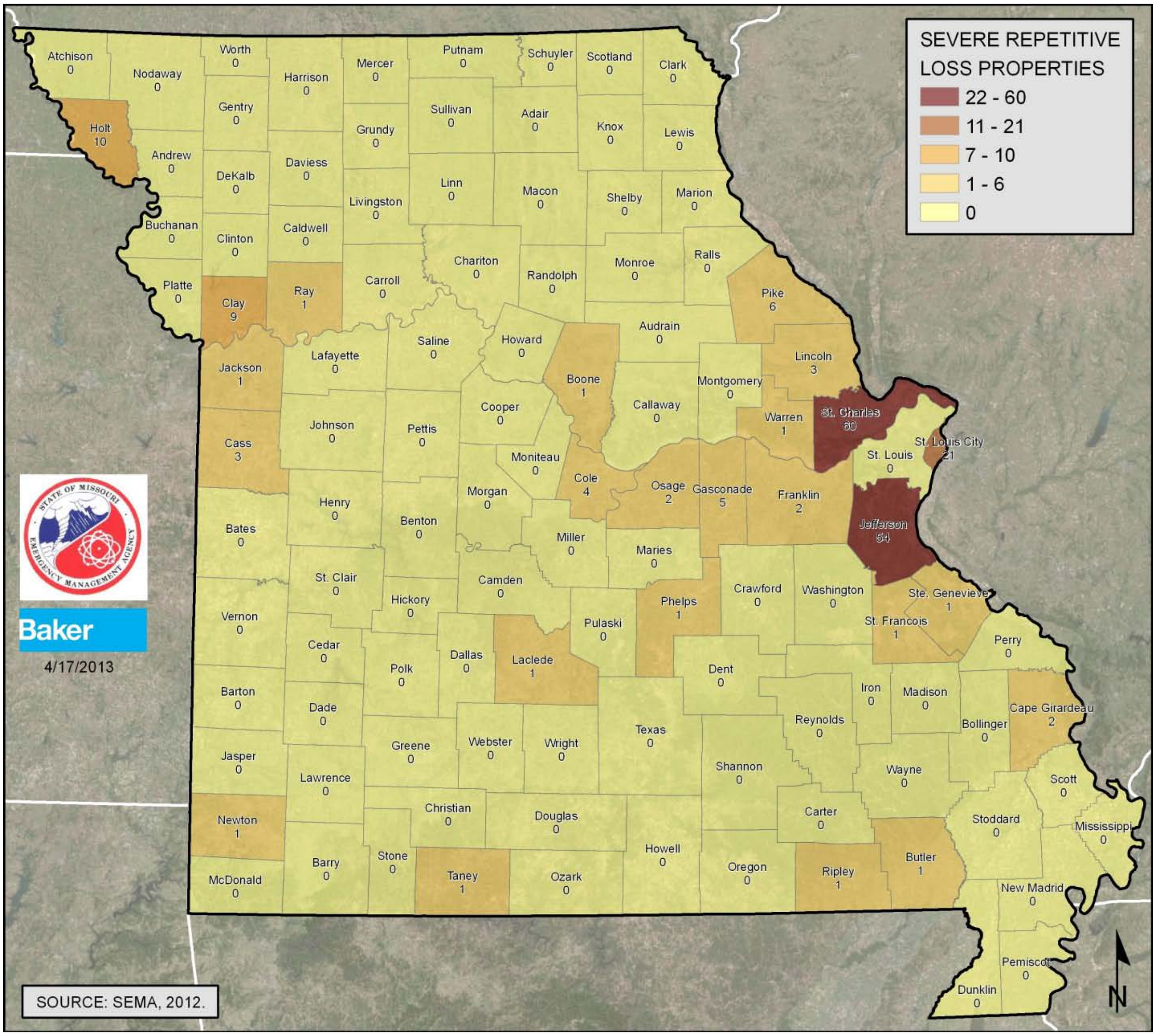


Table 7.5d below shows the mitigated buyout properties that are located in 42 Missouri counties.

Table 7.5d Mitigated Buyout Properties Since 2010 by County

Property Buyout Summary- (1993-2011)		
County Name	**# of Properties**	**Costs**
Bollinger	29	$960,540.00
Boone	10	$430,856.00
Buchanan	37	$1,021,929.00
Butler	61	$3,657,626.46
Cape Girardeau	111	$2,467,398.00
Carroll	64	$830,555.00
Cass	27	$1,676,690.00
Christian	1	$1,170,451.93
Clark	50	$1,136,932.00
Clay	72	$2,191,217.00
Cole	163	$1,882,415.00
Daviess	235	$3,851,920.00
Franklin	98	$6,697,080.00
Gasconade	55	$884,355.00
Greene	18	$1,519,612.00
Howard	65	$1,506,318.00
Howell	11	$940,837.00
Iron	16	$417,631.00
Jackson	40	$2,584,783.00
Jefferson	286	$11,243,479.00
Lewis	19	$1,126,809.00
Lincoln	373	$5,640,074.00
Madison	101	$3,476,200.00
Marion	177	$3,137,074.00
Newton	58	$1,966,488.00
Nodaway	1	$33,610.00
Perry	32	$760,179.00
Phelps	12	$378,241.00
Platte	18	$465,964.00
Pulaski	18	$505,225.00
Ray	3	$80,931.00
Reynolds	86	$3,648,732.00
Ripley	24	$978,180.00
Scott	31	$796,377.00
St. Charles	1176	$15,547,500.00
St. Francois	6	$348,751.00
St. Louis	524	$20,526,037.00
St.Charles	8	$156,856.00
Ste. Genevieve	80	$1,038,734.00
Taney	7	$217,108.00
Texas	1	$194,150.00
Warren	14	$650,246.00
Wayne	125	$5,088,936.00
TOTAL	**4343**	**$113,835,027.39**

Source: BureauNet, December 2009

Tornado Safe Rooms (M5)

In Missouri, only flood mitigation projects are prioritized ahead of projects that mitigate tornadoes and high winds. As shown in Table 7.5e and Figures 7.5.3, 7.5.4, and 7.5.5, between 2002 and 2009 60 tornado safe rooms were funded and 57 had completed construction in Missouri, primarily with PDM funding. Since the 2010 update, an additional 89 safe rooms have been funded, of which, 5 were completed, 19 are under construction, and 65 are in the design phase. Most are using either PDM or HMGP funding. 76 of those funded safe rooms were approved after the May 2011 Jasper Tornado. As of the 2013 update Tornado safe rooms have proven to protect people from tornadoes and high winds when built to FEMA construction standards. Projects include safe rooms in homes that protect individual families as well as large-scale school and community safe rooms, which often meet multiple community objectives (e.g., serving as both a school gymnasium and a safe room).

Table 7.5e Safe Room Current Phase Status' (Broken down by the year it was funded)

Phase	2003-2008	2009	2010	2011	2012	Current Phase Total
Design	0	0	10	1	54	**65**
Construction	0	3	14	1	4	**22**
Completed	52	5	4	0	0	**61**
Yearly Total	**52**	**8**	**28**	**2**	**58**	***148***

Source: SEMA

The funding of tornado safe rooms supports the goals and objectives of this plan as indicated in Table 7.5b and Table 7.5c. The program also supports the State's mitigation strategy for ensuring continued effective use of resources by demonstrating how partnerships with other State and local agencies can be used to leverage funding.

Figure 7.5.3 - Number of Safe Rooms Per County in the Design Phase as of May 2013

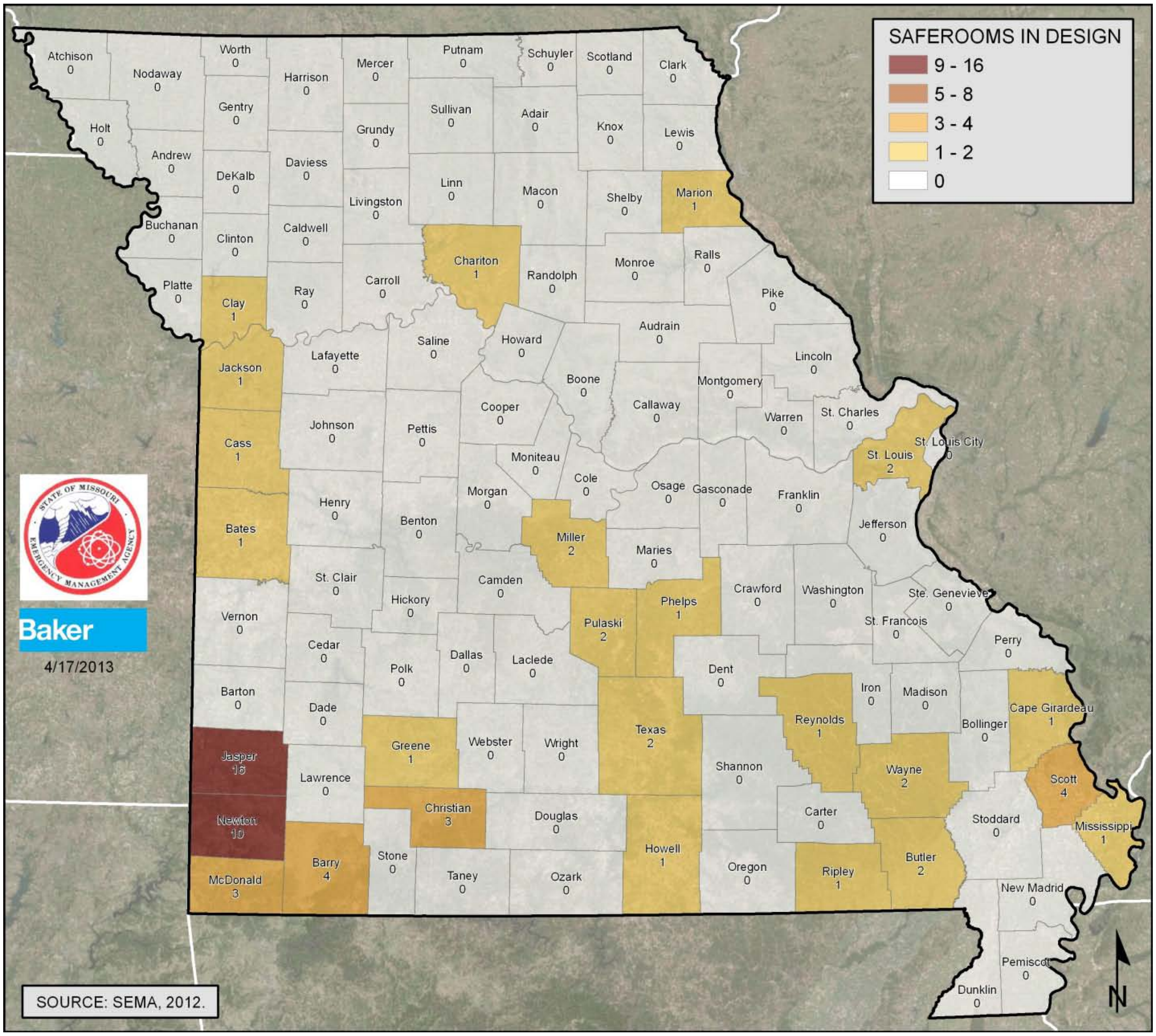


Figure 7.5.4 - Number of Safe Rooms Per County in the Construction Phase as of May 2013

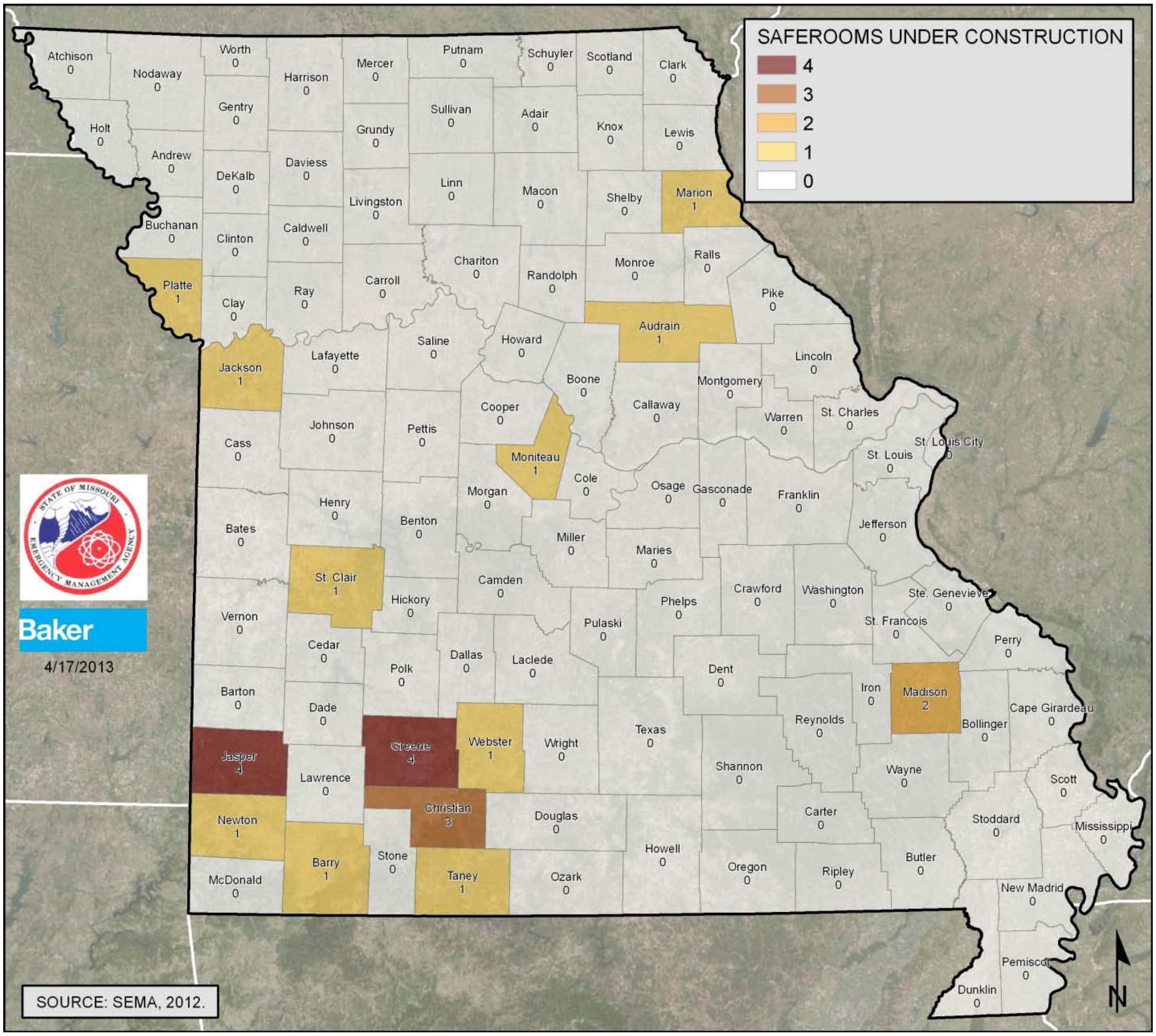
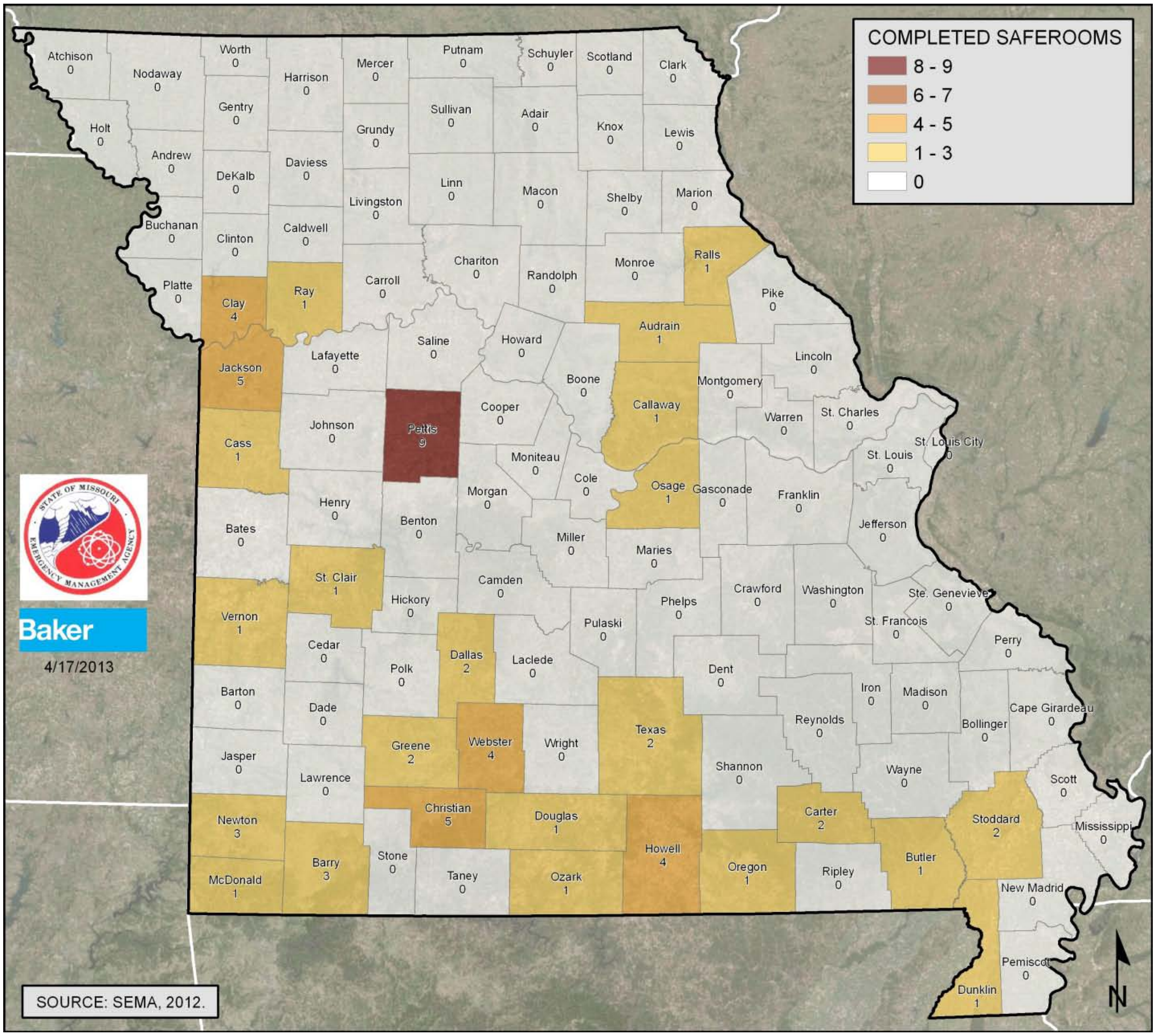


Figure 7.5.5 - Number of Safe Rooms Per County Completed as of May 2013



M7—Earthquake/High Wind Nonstructural Mitigation Projects

During February and March 2010, hundreds of Missourians took advantage of free earthquake public awareness events offered by SEMA and DNR's Division of Geology and Land Survey (DGLS). Free events were offered in St. Louis, Leasburg, Malden, Kennett, Piedmont, Jefferson City, Sikeston and Festus. At these public events, school children, residents and business planners asked questions and collected earthquake safety and mitigation information to protect their families and their property before a catastrophic earthquake occurs.

Figure 7.5.6 - Earthquake Mitigation for Homeowners Workshop

Source: SEMA Newsletter, Spring 2010

Public Outreach (M10 and M11)

SEMA also makes a considerable effort to educate the public, local officials, government officials, schools, private associations, and businesses about the value and importance of mitigation programs (see Figure 7.5.6). SEMA offers mitigation workshops, participates in public forums, provides one-on-one counseling, presents at conferences, provides written materials, develops guidebooks and manuals, publishes success stories, sends out press releases, offers information on the Internet, and provides training materials to local emergency managers, earthquake program partners, floodplain managers, and businesses.

Specifically, SEMA staffs a mitigation booth and frequently makes presentations at the annual Emergency Management conference. In addition, to promote the concept and value of mitigation, SEMA issues press releases after FEMA makes HMA grant awards to notify the public of the mitigation project being funded.

SEMA's public outreach efforts support all the goals of this plan, as increased public awareness is an objective under every goal (see Table 7.5b and Table 7.5c and Section 4.1 Hazard Mitigation Goals and Objectives). These efforts also support the State's mitigation strategy for ensuring continued effective use of resources through a wide array of partnerships (common partnerships for public outreach include

public and private radio and television stations, public and private school organizations, and service organizations (e.g., Lions, Rotary, and Elks clubs) and volunteer organizations (American Red Cross).

Annual Hazard Mitigation Assistance Grants Application Assistance (M11)
As documented in Section 4.4.5 Review and Progress of Mitigation Actions, Missouri has in the past successfully secured funding for local mitigation plans and projects and State mitigation planning funds from the annual, nationally competitive Pre-Disaster Mitigation (PDM) grant program since 2002. One of the reasons for this success is the hands on technical assistance that SEMA provides to sub-applicants in their grant applications and benefit-cost analyses. This has been provided through annual contractor supported Hazard Mitigation Assistance grant workshops. These two day workshops consist of HMA grants and BCA training. In 2009, 2010 and 2011 the BCA training was offered twice as a result of updates to the module. In addition to this training, the SEMA mitigation website provides links to FEMA's online BCA training as well as the BCA software.

This assistance supports all the goals of this plan by educating eligible State, local, and nonprofit entities in how they can secure funding for mitigation planning and projects. It also supports the State's mitigation strategy for ensuring continued effective use of resources by educating subgrantees about the process (as well as the State goals and objectives) to maximize the amount of PDM funding granted to Missouri. Projects are screened during the application process to determine if they align with local and State mitigation goals.

Other Mitigation Actions
From time to time, other types of mitigation projects have been warranted if proven to be cost-effective solutions to problems. For example, based on documented damage to power lines, it became possible to bury those lines from the street to the meter on residences as a cost-effective mitigation measure to the adverse effects of severe weather (M9). These projects have been required to fulfill all the requirements for flood mitigation projects and possibly have had other additional requirements depending on the nature of the project.

Other actions implemented or obligated since the 2007 update include flood elevations (M4), culvert/bridge replacements (M8), detention basins (M8), low water crossings (M8), electrical service line burials (M9), high wind retrofits (M6), generators (M10), and sirens (M7). The Missouri Department of Transportation designs new bridges and retrofits old bridges, including several in St. Louis, to resist seismic impacts (M6 and M8). To see how these actions meet the goals and objectives of the State, see Table 7.5b and Table 7.5c. More information about these activities can be found in Section 4.4 Mitigation Actions.

7.5.1 Mitigation Success

The State mitigation program encourages and motivates State and local government agencies, as well as the private sector and the general public, to mitigate hazards and establishes priorities for hazard mitigation programs in all areas of the State. To establish these priorities, the Hazard Mitigation Planning Team reviewed existing State statutes, ongoing mitigation initiatives, proposed mitigation initiatives/projects, and completed mitigation projects. The review of completed mitigation projects focused on the projects' overall success and contribution toward meeting the goals and objectives of the State and applicable local mitigation program.

Following are some examples of successful mitigation programs and projects. This list is not all-inclusive, but does include the efforts that have been deemed the most successful and/or beneficial to the overall mitigation program.

The State Hazard Mitigation Program

The State, through SEMA, has instituted an effective and comprehensive all-hazard mitigation program. Through the wise use of available federal Hazard Mitigation Assistance grants and State funds (e.g., Hazard Mitigation Grant Program, Public Assistance, Unmet Needs, Project Impact, Pre-Disaster Mitigation, Flood Mitigation Assistance, Community Development Block Grants, Department of Natural Resources Stormwater Grants, Natural Resources Conservation Service, etc.) the State has been able to successfully mitigate many areas against the devastating effects of future disasters.

SEMA also leverages FEMA guidebooks and Missouri specific information, which is shared as "commonly required revisions." This information is periodically emailed to the RPCs pto keep them in touch with common FEMA revision requests. SEMA also shares various resources that come available such as webinars and other applicable resources.

History and a working relationship with State partners such as the State Historic Preservation Office and the Missouri Department of Conservations are indicators of SEMA's commitment to be able to prepare environmental documentation. Historically, SEMA has performed or reviewed all benefit-cost analyses for hazard mitigation grant applications and has successfully trained local jurisdictions to complete them. All current mitigation staff members have received formal FEMA benefit-cost training and use the software on a regular basis to keep knowledge and skills current.

During the 1993 Midwest floods, an interagency hazard mitigation team (IHMT) was formed. This team was composed of representatives from FEMA, SEMA, and various State agencies/departments (Governor's Office, Department of Economic Development, Department of Natural Resources, Department of Transportation, and others). The 1993, 1994, and 1995 buyout projects were selected, coordinated, and managed by a small committee appointed by the governor for this specific purpose. The wisdom in this approach can be found in the results as six months after hazard mitigation funding became available, all projects were approved.

This IHMT would later become the Hazard Mitigation Project Coordinating Group, now the SHMPT. While the name of this entity changed, its purpose remains the same. Following a significant disaster, hazard mitigation projects are coordinated through the representatives of the SHMPT. This coordination is primarily with representatives from the Department of Economic Development Community Development Block Grant section, the Missouri Department of Transportation, the Department of Natural Resources Historic Preservation office, and the U.S. Army Corps of Engineers. Other state and federal agencies are added to this group as the situation and mitigation issue dictates.

Specifically, following the 2008 floods, SEMA participated in the Silver Jackets Program (link). This coordination program was an Interagency Flood Risk Management Team that consisted of regional, state, USACE and FEMA partners and promoted the motto "Many Agencies, One Solution, Reducing Risk." The name Silver Jackets comes from the different colored jackets which various agencies wear when responding to disasters, such as, USACE personnel wear red and FEMA personnel wear blue. The

"Silver Jackets" represents a unified interagency team. Although this program officially expired in 2009, Missouri has continued this type of coordination by participating on the Regional Flood Risk Management Team and organizing the state "Silver Jackets" type of program composed of the State Risk Management Team (SRMT) formerly known as the State Hazard Mitigation Planning Team.

The mitigation process and the State's mitigation initiatives are ongoing. SEMA's mitigation staff in conjunction with other State and local agencies, continue to look for new opportunities and funding sources. The staff also continues to look at expanding existing mitigation initiatives and developing new ones. The primary focus for the use of disaster-related Hazard Mitigation Grant Program funds has been the flood buyout program and more recently the tornado safe room construction program.

The State also has an effective and proactive floodplain management program. Personnel from the Logistics, Resources, Mitigation and Floodplain Management Branch of SEMA are continually conducting assistance visits, trainings, and site inspections in communities throughout the State. These efforts ensure that local government, private enterprises, and the citizens of the State are aware of the benefits of participating in the National Flood Insurance Program, among other things.

As a result of the State's mitigation program, local governments and private industries have formed partnerships to make the State and their communities and residents safer and more prepared for the next potential disaster. Their actions will help ensure that future disasters have less of an impact on lives, property, and infrastructure in their communities and the State.

Missouri Community Buyout Program

In the aftermath of the summer of 1993 flood, the State launched an unprecedented statewide hazard mitigation effort in the form of the Community Buyout Program. This was a voluntary program designed to acquire residential properties in the floodplain and move residents out of harm's way. The buyout program utilized a mix of federal funds, including funds from the Hazard Mitigation Grant Program, Public Assistance, and Missouri Community Development Block Grants. Then-Governor Mel Carnahan conservatively estimated the buyout program would save Missouri an estimated $200 million in flood fighting costs, Individual Assistance, and flood insurance claims over the next 20 years.

But, no one could predict Missouri would have the opportunity to test the buyout's effectiveness as quickly as it did when the spring 1995 flood, the third worst flood on record in many places, struck. Due to the buyout program, there were some 2,000 families no longer living in the floodplain. Removing these flood prone properties from harm's way saved millions in disaster assistance and emergency protective measures statewide.

Participating buyout communities were able to focus their efforts on the flood response. They did not have to use their limited resources on evacuating residents or sandbagging structures to save private property in the floodplain. Likewise, claims for flood insurance and applications for assistance, such as Small Business Administration and Individual and Family Grant (IFG) Program loans, were minimized.
The flood of 1995 was significantly equal to the flood of 1993 in the majority of communities that undertook a flood buyout program after the 1993 flood. The cost of human suffering was dramatically reduced in 1995, however, thanks to the buyout program and the associated demolition of about two-thirds of the flood-prone homes after the flood of 1993. This meant that fewer people were in harm's way during the flood of 1995, thanks to Missouri's highly successful buyout program. Flood insurance

claims payments on flood buyout properties, totaled more than $22.6 million for the 1993 and 1995 flood events. Because of the buyout program these claims will never be paid out again.

The flood of May 2007 (DR 1708) drew parallels to the 1993 flood, causing significant damage along the Missouri River, and generated more success stories for the buyout program. In one example, 17 properties had been acquired in the City of Tracy for approximately $450,000. In some areas of Tracy, recent water levels exceeded those of the 1993 flood. Had they not been removed, those 17 homes would have been inundated with flood waters and cost the city and homeowners hundreds of thousands of dollars. Additionally, the spring and summer floods of 2008 (DR-1749 and DR-1773) impacted eastern Missouri. The loss avoidance study conducted by FEMA following these flood events, as presented in Section 7.4.2, demonstrates the cost-effectiveness of the buyout program with losses avoided valued at $96.3 million and a return on investment of 21.2 percent.

Table 7.5.1a highlights a historical success story that includes some of the key data relating to the success of the Missouri buyout program. It provides data comparing the buyout programs for the 1993 and the 1995 flooding disasters in Missouri. The table provides a good comparison to highlight the overall success of the Missouri buyout program.

Table 7.5.1a Missouri's Buyout Success Story

	Total	1993	1995
Total Number of Buyout Projects	48	45	3
Number of Parcels Acquired*	4,193	4,044	149
Hazard Mitigation Grant to State**	$32.1 Million	$30.0 Million	$2.1 Million
Total Cost of Buyout Projects	$59.1 Million	$56.8 Million	$2.3 Million
Total Flood Insurance Claims Paid***	$22.7 Million	$22.1 Million	$563,393.00
SBA Loans Repaid (45%)	$5.7 Million	$5.4 Million	$321,542.00
Property Acquired: (Fair Market Value)****	$78.1 Million	$75.2 Million	$2.9 Million

Source: State Emergency Management Agency

Notes:

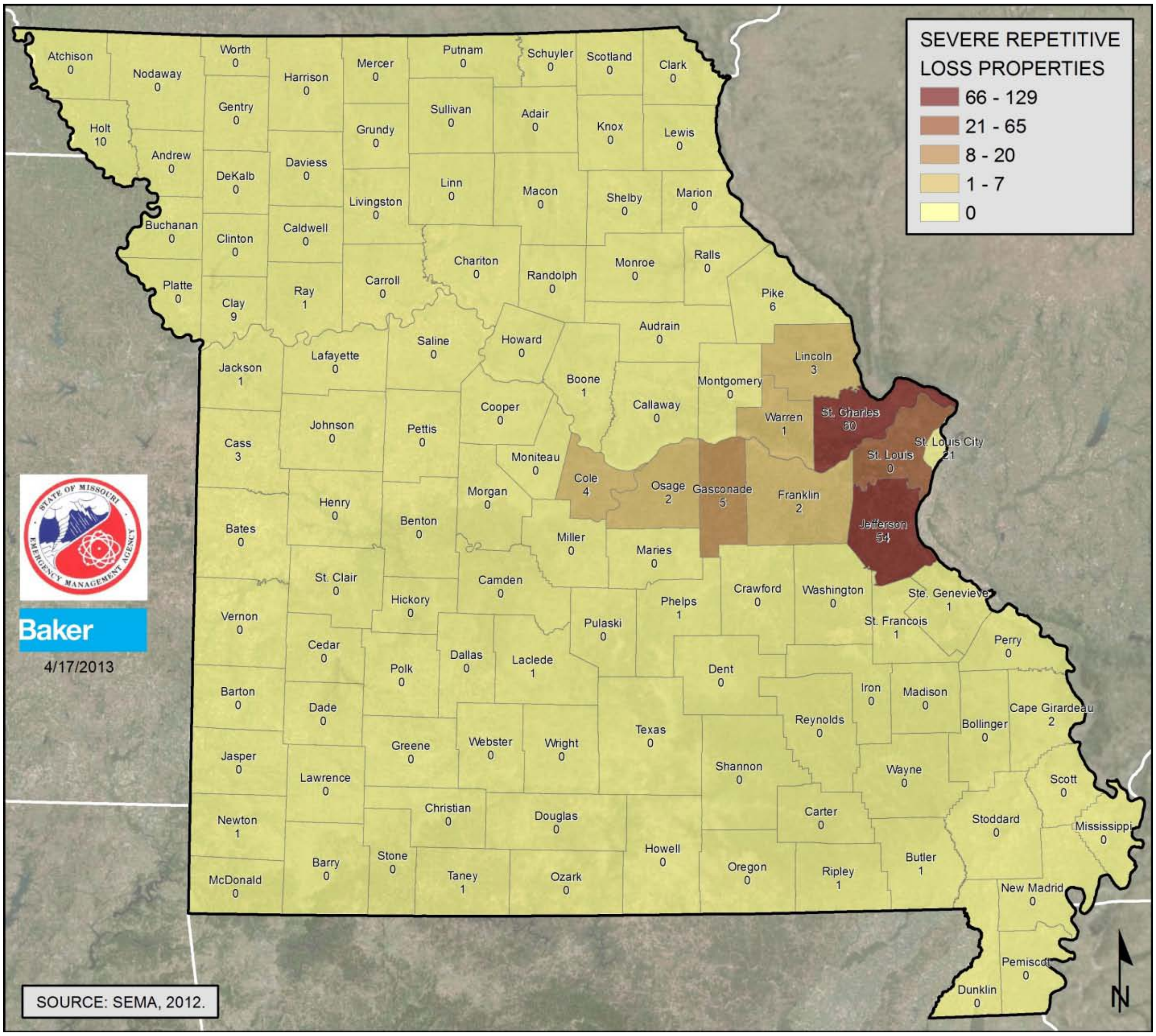
*Missouri only received $2.1 million in HMGP funds in 1995 as compared to $30 million after the 1993 flood.

**Through local governments, the Missouri was able to acquire 4,044 properties after the flood of 1993 for roughly $56.8 million. This is an average cost of $14,045. Although the properties had an average pre-flood fair market value of $18,500, because of flood payments paid prior to closing and deducted from the pre-flood value, the cost to acquire flooded properties was considerably less to the state.

***Small Business Administration (SBA)—The flood claims paid out on property acquired through the buyout in 1993 was more than $22.1 million. Only $563,393 was paid out in 1995 on the homes that were eventually acquired after the 1995 flood. Additional assistance of more than $4 million was also paid by FEMA to property owners participating in the buyout. Again, these payments will NEVER be paid again.

****Of the more than $1.9 million in SBA loans paid out on flood-damaged property, $5.4 million was repaid by property owners at the time of the buyout closing. In 1995, 100 percent of SBA loans paid out on flood-damaged property were repaid at the time of closing.

Figure 7.5.1.1 - Severe Repetitive Loss Properties



Since the 1993 floods, over 4,000 primary residences have been acquired through the buyout program. This voluntary program has allowed families in flood-prone areas to relocate out of harm's way and reduced disaster-related costs. Figure 7.5.1.1 shows, by county, where the severe repetitive loss properties were located and bought out. The acquired properties were placed in public ownership with deed restrictions to ensure that future use of these lands will not put the lives of Missouri residents at risk from flood disasters. The document *Past Mitigation Projects* contains Community Buyout Program statistics through fiscal year 2009.

Some communities have continued this program by using local funds to acquire flood-prone properties. This is a clear example of the positive impact of advertising mitigation success stories. Because of the success of this program, the acquisition of flood-prone structures continues to be a priority for the use of hazard mitigation funds available to the State.

For additional information on the tremendous success of the Missouri Buyout Program, refer to the following hyperlinked documents:

- *Loss Avoidance Study: Eastern Missouri, Building Acquisition Part One: General Overview and Part Two: Detailed Methodology"*
- *Stemming the Tide of Flood Losses*
- Missouri Flood Mitigation Project
- Success Stories from the Missouri Buyout Program

Safe Room Construction Program
As of April 2013, 61 tornado safe rooms have been constructed, 22 are in the process of being constructed, and 65 are being designed utilizing FEMA Hazard Mitigation Assistance grants totaling over $170 Million. Since the approval of the 2010 State Mitigation Plan, half of the Presidential Disaster Declarations in Missouri included devastating tornadoes. The State of Missouri is committed to setting a standard in the State for safe room construction, ensuring that all funded safe rooms are constructed in accordance with FEMA design standards. The newly developed Loss Avoidance Tool described in Section 7.4.2 of this chapter has functionality to assess the effectiveness of the safe room program.

In late 2009/early 2010, SEMA's Hazard Mitigation Section closed out three community safe room projects. Another four community safe room projects were closed out in late 2010/early 2011. During a closeout visit, mitigation staff takes photos of the completed mitigation project and makes sure the community has all the required paperwork easily accessible if a federal audit is conducted for the project.

Figure 7.5.1.2 - Severe Repetitive Loss Properties Licking R-VIII School District Safe Room

Figure 7.5.1.2 shows the Licking R-VIII School District (Texas County) safe room/gymnasium project has a maximum occupancy of 1784 people. The project was funded by a 2007 Pre-Disaster Mitigation Grant.

Figure 7.5.1.3 - Pettis County's LaMonte Community Safe Room

Figure 7.5.1.3 shows the Pettis County Commission managed the community safe room mitigation project for the community of LaMonte. The county secured a hazard mitigation grant from the April 2006 tornado federal disaster declaration. The community safe room is a single-use underground unit, which has a maximum occupancy of 946 people.

Figure 7.5.1.4 - Holts Summit Community Safe Room

Figure 7.5.1.4 shows the Holts Summit (Callaway County) used a 2007 Pre-Disaster Mitigation grant to build an underground community safe room with a maximum occupancy of 723 people. The new city hall was built on top of the underground unit. The safe room also serves as the Community Emergency Response Team (CERT) training room.

Another specific example of the success of this program is the monolithic dome safe room for the Niangua R-V School District in Webster County. This dome-shaped safe room doubles as a preschool classroom and is the first of its kind approved for FEMA funding. This safe room, funded out of the FY2006 appropriation of the PDM grant program will hold approximately 400 people and meets FEMA's criteria for the design and construction of community safe rooms. The new dome-shaped building cost just over $300,000. Monolithic domes are known not only for their safety, but also for their energy efficiency. A dome can cost as much as 50 percent less to heat and cool than a traditional structure of the same size. Also, because of the materials used in their construction, they are also fire-safe.

Local Mitigation Planning Program

This project was established to develop local hazard mitigation plans that meet the requirements of the Disaster Mitigation Act of 2000. Funding for local hazard mitigation plans has come primarily from Hazard Mitigation Grant Program funds and Pre-Disaster Mitigation funds. This effort showcases the coordination between the State and the Regional Planning Commissions and Councils of Government

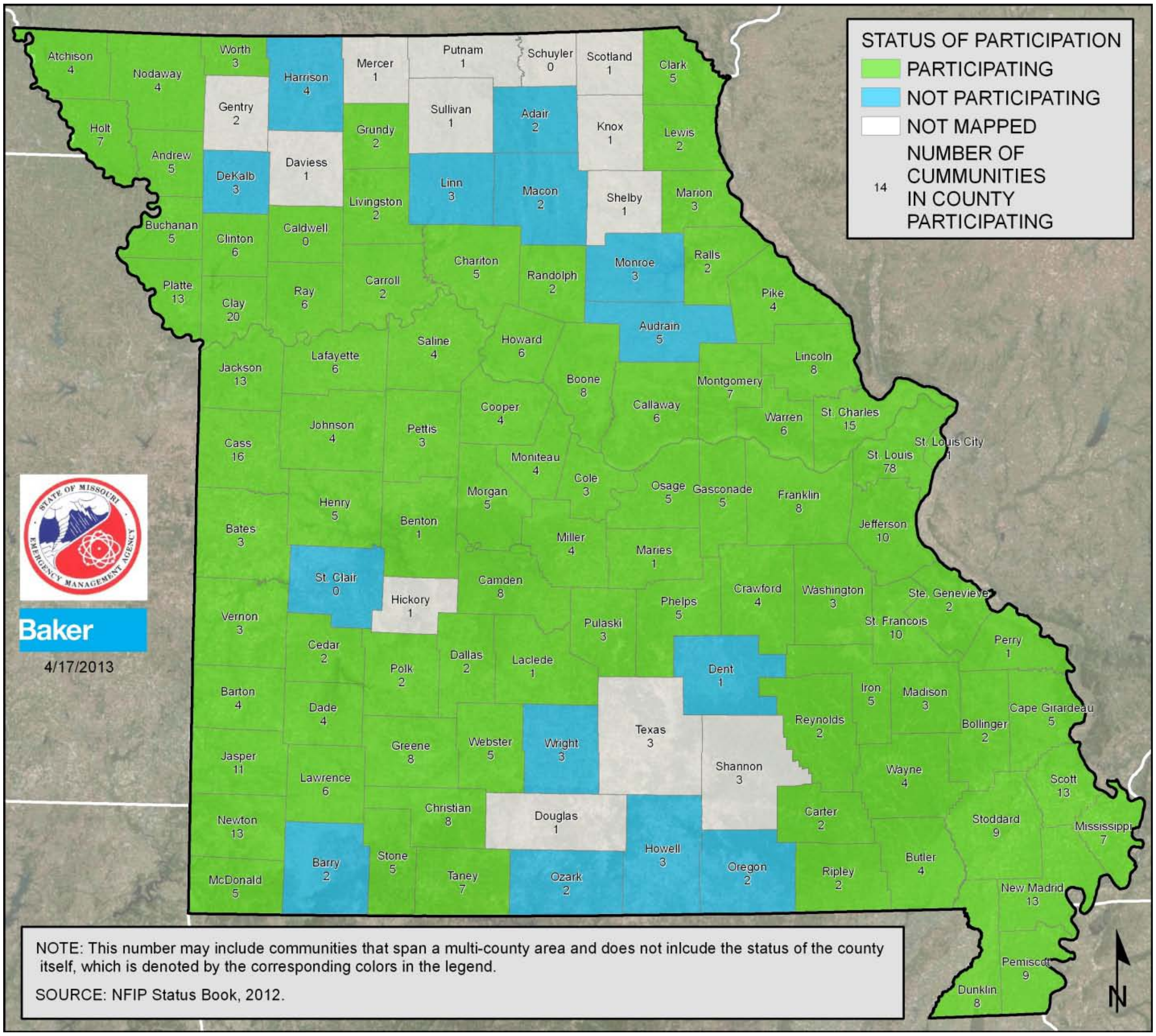
throughout the State, the represented local communities, business and industry, as well as concerned private citizens. As of early 2010, 94 percent of Missouri's population was covered by a FEMA-approved local mitigation plan. The success of this effort is documented in more detail in Chapter 5 Coordination of Local Mitigation Planning.

National Flood Insurance Program

In Missouri, the National Flood Insurance Program (NFIP) has shown remarkable progress over time. When SEMA took responsibility for administration of the State's floodplain management program in 1995, there were 523 jurisdictions in the National Flood Insurance Program. As of April 2013, there were 652 participating jurisdictions: 650 communities in the regular program and 2 communities in the emergency program. All the participating communities have established local floodplain management ordinances to help them administer the program.

There were 161 jurisdictions in Missouri that are not in the National Flood Insurance Program (NFIP) that have hazard areas identified. Nine of those 161 jurisdictions had their hazards areas identified for less than one year, a reflection of the new mapping initiatives taking place in Missouri, 8 were suspended from the regular program, and one has withdrawn from the program. The locations of participating and nonparticipating communities are mapped by county in Figure 7.5.1.5.

Figure 7.5.1.5 - Missouri Communities Participating in NFIP



Department of Natural Resources Stormwater Improvements

In 2001, the Missouri Department of Natural Resources (DNR) awarded more than $9.9 million to 46 Missouri communities for stormwater improvements. As shown in Figure 7.5.1.5, of these 46 communities, 7 of them had populations of 3,000 or less. Funding for these grants came from bond issues approved by Missouri voters in 1988 and 1998 for improvements to stormwater, wastewater treatment, and public drinking water systems. Additionally, during the drought of 2012, the Missouri Department of Natural Resources administered loans and grants to farmers that assisted with the construction of agricultural wells to alleviate water shortages caused by the drought.

Types of projects approved by DNR included, but were not limited to:

- Drainage modifications to prevent pooling water, reduce streambank erosion, reduce localized flooding, and improve discharge water quality
- Buyout and demolition of flood-prone homes

- Replacement of undersized drainage systems to prevent flooding of houses and streets
- Channel stabilization and drainage improvement
- Modification of existing detention basin outlet for better storage capacity and to help avert downstream flooding
- Development of city- and county-wide stormwater management plans
- Construction of stormwater collection and control systems
- Combinations of biostabilization measures and upstream detention to alleviate existing erosion and to prevent future channel degradation based on anticipated future development conditions
- Construction of new storm sewer systems

CDBG Disaster Supplemental Funding

The State of Missouri received two separate CDBG Disaster Supplemental Appropriations related to the weather related events of 2008.

1) The Supplemental Appropriations Act of 2008 provided $300 million of CDBG supplemental funds for necessary expenses related to disaster relief, long-term recovery, and restoration of infrastructure in areas covered by a declaration of major disaster under Title IV of the Stafford Act. Missouri received $11,032,438 from this appropriation, and was limited to activities covered under Disaster Declarations 1760 and 1773.
2) The Consolidated Security, Disaster Assistance, and Continuing Appropriations Act (PL 110-329 and hereafter identified as the Second 2008 Act) appropriates over $6 billion in CDBG funds for necessary expenses related to disaster relief, long-term recovery, and restoration of infrastructure, housing and economic revitalization in areas affected by hurricanes, flooding and other natural disasters that occurred during 2008, for which the President declared a major disaster under title IV of the Robert T. Stafford Disaster Relief and Emergency Assistance Act. The allocation awarded to Missouri from this Supplemental Appropriation is $92,605,490. Of this allocation, an amount not less than $10,372,631 must be used for affordable rental housing. All but 8 Missouri counties were covered by at least one disaster declaration during 2008.

Missouri has awarded 99 percent (net of state administration) of the 1st supplemental appropriation on projects specifically related to disaster events 1760 and 1773, as required by the Act. These projects consist of mostly infrastructure restoration projects, plus some commercial and residential buyout.
By April 2010, Missouri had formally awarded approximately half (net of state administration) of the 2nd supplemental appropriation on projects in the disaster affected areas, as required by the Second 2008 Act. These projects consist of infrastructure restoration, job training, and economic revitalization in the disaster declared areas. Applications are still under review, and 100 percent of the appropriation will be awarded for eligible projects in the disaster declared areas.

In addition, Missouri used existing CDBG funding (recaptured funds and program income) to address flooding events in early 2008 for which no supplemental appropriation was yet available. A total of 13 projects were awarded for levee repair and acquisition of flood affected homes; the amount awarded was $2.8 million. This is in addition to the supplemental funding.

Click here for a detailed listing of CDBG awards from 2008 to April 2010.

In 2012 CDBG received a supplemental for 2011 events. Section 239 of the Department of Housing and Urban Development Appropriations Act, 2012 (Public Law 112-55, approved November 18, 2011) makes

available up to $400 million, to remain available until expended, in CDBG funds for necessary expenses related to disaster relief, long-term recovery, restoration of infrastructure and housing, and economic revitalization in the most impacted and distressed areas resulting from a major disaster declared in 2011 pursuant to the Robert T. Stafford Disaster Relief and Emergency Assistance Act of 1974.

The State of Missouri Department of Economic Development (DED) has been awarded $8,719,059 from this appropriation. The federal disaster declarations that are specific to this supplemental appropriation are 1980 and 4012. Only areas included in one of these disaster declarations are eligible to apply for and receive CDBG assistance from this Disaster Appropriation.

Tornado Safe Room Projects

Over the past three years, SEMA has developed several tornado safe room projects. One of the projects currently under development is located in St. Clair County, where 29 safe rooms are being constructed on the Bartle Scout Reservation (Boy Scouts of America). For this project, SEMA partnered with both St. Clair County and the Bartle Scout Reservation to develop and fund the $2.5 million project. Construction on this project is nearly complete, with the 29th and final safe room currently being built. This safe room will contain communications equipment for effective and efficient operations of the entire safe room network on the Boy Scout Reservation.

Tornado Sirens in Northwest Missouri

SEMA funded a network of tornado warning sirens in Northwest Missouri under the Hazard Mitigation Grant Program 5% Initiative. This project, which was led by the Northwest Regional Council of Governments was completed in September of 2009. The total project cost was $365,521.

Flood Buyout Projects

Between October of 2007 and October of 2011, SEMA administered 16 different flood buyout projects throughout the State. The combined federal shore for these projects was $11,975,590, while the non-federal share was $3,587, 301, and the total spent was $15,562,891.

Brush Creek Community Partners/Mitigation

When the Brush Creek Flood Control and Beautification Project was initiated in the 1980s, the decision was made for what is also known as the Federal Project to be constructed between Tracy Avenue and Roanoke Parkway. Since the completion of this phase in 1996, concern about the reach from Roanoke west into Kansas have intensified. The concrete that lines the channel has broken up, the banks are eroding and trees have fallen into the creek. The City of Kansas City, Johnson County, Kansas and the U.S. Army Corps of Engineers have collaborated to examine conditions in the entire 29 square mile watershed in order develop a comprehensive plan to improve flood risk management and water quality while balancing economic, environmental and social benefits. The Bi-State Reach between Roanoke and just into Johnson County is the first of a few specific areas being examined in the study.

DNR Dam Safety Program – New Technology Used to Create Dam Inundation Maps

The Missouri DNR's Water Resources Center has developed a procedure for creating dam inundation maps by augmenting field surveys with highly sophisticated imaging and geospatial software and equipment. These systems include high resolution LiDAR elevation data, HEC-Ras software, HEC-GeoRAS, and Digital Elevation Model (DEM) data.

Reservoirs, Levees, and Flood Walls

During the Great Flood of 1993, flood damage reduction structures prevented an estimated $19.1 billion in potential additional damage, according to the May 26, 1994, *Draft Report of the Interagency Floodplain Management Review Committee*. Of that, it is estimated that at least $11.5 billion damage was prevented along the Missouri River: $7.4 billion was attributed to management of floodwater stored in reservoirs and $4.1 billion was attributed to levees. Reservoirs, levees, and flood walls prevented damage of approximately $5.6 billion in Kansas City.

Another study, conducted by a former U.S. Army Corps of Engineers (Corps) District engineer, estimated flood damage in the St. Louis district of the Corps at $1.4 billion. At the same time, the study estimated damage prevented by federal flood damage reduction efforts at $5.4 billion. Thus, an 80 percent reduction in potential damage was achieved in the St. Louis Corps district.

Missouri Bridges Constructed to Withstand Earthquakes

The Missouri Department of Transportation (MoDOT) began designing bridges to resist seismic hazards in 1990. However, many of the nearly 2,000 bridge structures in earthquake-prone portions of the State were not designed to resist seismic induced forces. Several structures in St. Louis that were designed and constructed before 1990 have been retrofitted to resist seismic induced forces.

As shown in Figure 7.5.1.6, construction of the retrofit of Poplar Street Bridge in St. Louis, Missouri was completed in late 2002 at a cost of $6.2 million. This 2,165 foot bridge carries more than 130,000 vehicles per day across the Mississippi River.

Figure 7.5.1.6 - Pier 1 Retrofits on the Poplar Street Bridge, St. Louis, Missouri

Source: Seismic Retrofit of the Popular Street Bridge, Mark R. Capron

National Oceanic and Atmospheric Administration Weather Radio All Hazards

The National Oceanic and Atmospheric Administration (NOAA) Weather Radio All Hazards (NWR) is an all-hazards public warning system that broadcasts forecasts, warnings, and emergency information 24 hours a day. The National Weather Service has responsibility for the NWR. Tone alert radios receive the broadcasts and can be programmed to sound when severe weather watches, warnings, or other critical information is broadcast. They are designed to automatically sound when warnings are issued.

The NWR project increased the number of NOAA weather warning transmitters in Missouri from 10 in 1998 to 34 in 2007 (See Table 7.5.1b). Every county in the State is covered by a NOAA Weather Radio transmitter. However, due to hills and other issues that cause signal blockage, there are areas that cannot pick up a strong signal. Approximately 95 percent of the State can receive NWR broadcasts (see Figure 7.5.1.7). This success story is a result of the cooperative efforts of State, federal, and local government; private citizens; business and industry; and the State's electric cooperatives.

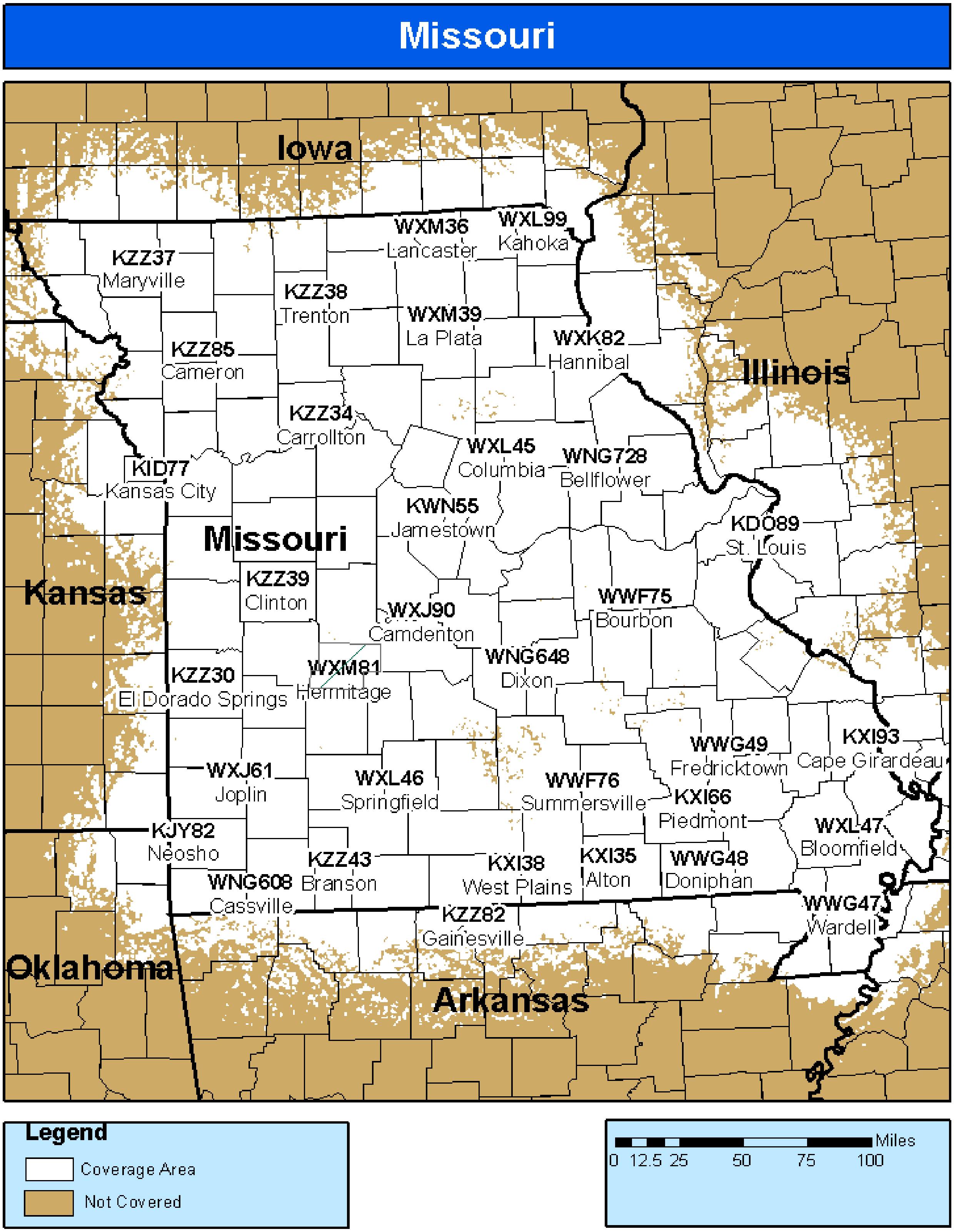
The expanded severe weather warning coverage provided by these transmitters benefits everyone in the State. By providing early warnings for severe weather, these transmitters enable people in the affected areas to take cover and protect themselves from severe weather.

Table 7.5.1b Missouri NOAA Weather Radio Stations

Site Name	Site Location	Call Sign	Frequency	Power
Alton	Alton	KXI35	162.5	300
Bellflower	Montgomery County	WNG728	162.45	1000
Bloomfield	Idalia	WXL47	162.4	1000
Bourbon	Crawford County	WWF75	162.525	1000
Branson	Reeds Spring	KZZ43	162.55	1000
Camdenton	Osage Beach	WXJ90	162.55	1000
Cameron	Cameron	KZZ85	162.475	300
Cape Girardeau	Cape Girardeau	KXI93	162.55	300
Carrollton	Carrollton	KZZ34	162.45	1000
Cassville	Cassville	WNG608	162.525	300
Clinton	Shawnee Mound	KZZ39	162.5	1000
Columbia	Fulton	WXL45	162.4	1000
Dixon	Fort Leonard Wood	WNG648	162.425	1000
Doniphan	Doniphan	WWG48	162.45	1000
El Dorado Springs	El Dorado Springs	KZZ30	162.475	1000
Fredricktown	Fredricktown	WWG49	162.5	1000
Gainesville	Gainesville	KZZ82	162.425	1000
Hannibal	Hannibal	WXK82	162.475	1000
Hermitage	Lake PomDeTerre	WXM81	162.45	100
Jamestown	Prairie Home	KWN55	162.425	1000
Joplin	Avilla Carthage	WXJ61	162.425	1000
Kahoka	Kahoka	WXL99	162.45	300
Kansas City	Independence	KID77	162.55	1000
La Plata	La Plata	WXM39	162.525	330
Lancaster	Lancaster	WXM36	162.55	300
Maryville	Maryville	KZZ37	162.425	1000
Piedmont	Sanders Hollow	KXI66	162.425	1000
Saint Joseph	Wathena	KEC77	162.4	1000
Springfield	Fordland	WXL46	162.4	1000
St. Louis	Shrewsbury	KDO89	162.55	1000
Summersville	Summersville	WWF76	162.475	1000
Trenton	Galt	KZZ38	162.5	1000
Wardell	Gideon Junction	WWG47	162.525	300
West Plains	West Plains	KXI38	162.525	300

Source: National Weather Service

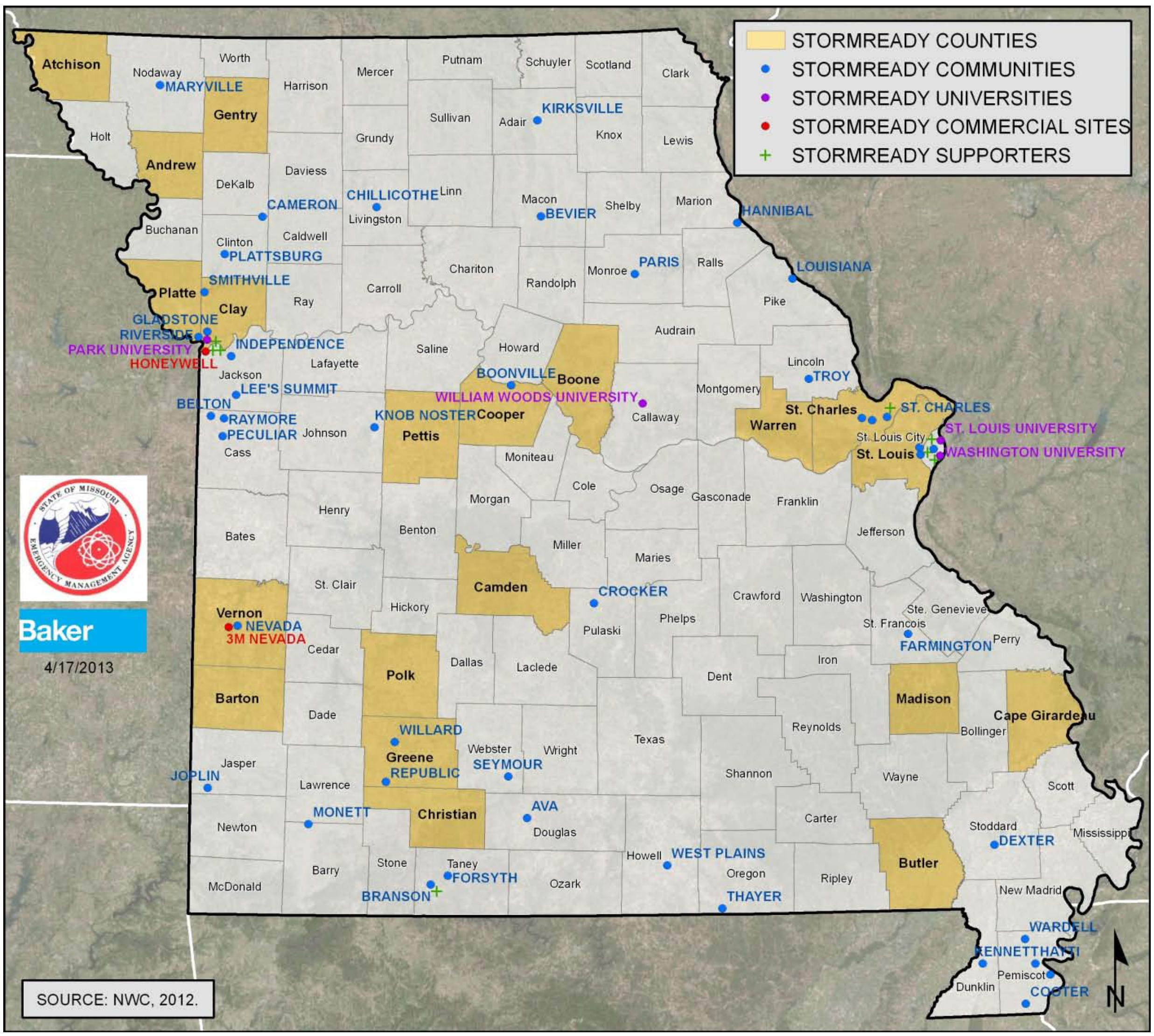
Figure 7.5.1.7 - Missouri's NOAA Weather Radio Coverage



National Oceanic and Atmospheric Administration (NOAA) StormReady Program

Since the 2007 plan, Missouri has continued to make progress in preparing its communities for severe weather. In 2004, there were 7 counties, 20 communities, and 1 commercial site in the StormReady program. In early 2007, there were 16 counties, 25 communities, 1 commercial site (there are only 5 nationwide), and 1 university. In early 2010, there were a total of 53 StormReady designations, including 16 counties, 34 communities, 2 commercial sites, 1 university, and 2 supporters. As up May 2013, there were a total of 78 StormReady designations, including 20 counties, 44 communities, 2 commercial sites, 4 universities, and 8 supporters. Missouri's current StormReady designations are illustrated in Figure 7.5.1.8.

Figure 7.5.1.8 - Missouri's StormReady Designations



Source: National Weather Service

Notes: Gold Shading: StormReady County Purple Dot: StormReady University

Blue Dot: StormReady Community Red Dot: StormReady Commercial Site

Disaster Resistant Community Program

Although the program has ended, the State of Missouri's Disaster Resistant Community program, in conjunction with the former FEMA Project Impact program was labeled a great success. Through this initiative, the civic and political leaders of eight communities developed and instituted sound mitigation actions in their respective communities. While only eight communities are formally recognized as "Disaster Resistant Communities," the Hazard Mitigation Planning initiative promotes similar strategies as communities develop partnerships and a strategy with an ultimate goal of being resistant to the impacts of disasters through a whole community approach. As discussed previously, as of early 2010, the majority of Missouri communities had local hazard mitigation plans and many were implementing hazard mitigation activities.

Other Mitigation Projects

The following success stories highlight the potential for future loss reduction and how mitigation projects have been successful in meeting multiple community objectives and effectively leveraging partnerships.

City of Neosho

This city has successfully developed a stormwater utility and has used the funds to create detention basins and improve the aesthetics of the downtown area. These efforts were spurred by participation in an earlier flood buyout program, where the success of mitigation was apparent to the residents and leaders of this community.

Kansas City

Kansas City used its own tax revenue to elevate a low bridge that had been overtopped by a flash flood in 1998 that killed eight people. The Prospect Bridge was elevated in conjunction with creek stabilization and open space improvements using "No Adverse Impact" principles of floodplain management. The very weekend the bridge was dedicated in October 2004, the area experienced heavy rains that could have resulted in flooding if the bridge had not been replaced.

City of Piedmont

This city has an annual creek cleanup, in cooperation with the Department of Conservation and the Natural Resource Conservation Service. This is an example of a true community cooperative effort that involves these agencies as well as local volunteers, including local boy scouts. The cleanup helps reduce flooding by reducing channel clogging debris. The aesthetics of the community are improved and the environmental benefits include improved habitat for fish.

Hannibal

The Mississippi River has always been a threat to Hannibal; and after eight close calls over three decades, local businessmen, banks, and city government raised the $850,000 local share for a $5.8 million flood wall. The wall, which was constructed between the town and the river, was completed barely one year before the 1993 flood. The U.S. Corps of Engineers estimated that the wall prevented $14.5 million in damage to downtown Hannibal, more than two times what it cost.

Other areas of Hannibal did not fare so well. Because of the large number of homes that were damaged, the State was quick to initiate a buyout program. The program proved to be successful when, in 1995,

another flood struck Hannibal. This time though, no one was forced from their homes, and no homes were ruined. The people and their homes had been moved out of harm's way. In all, 116 homes were purchased in Hannibal through the buyout program, and the land, once a problem, is now an asset, serving a variety of recreational, even revenue generating, purposes.

City of St. Joseph Manufactured Home Park Shelter Ordinance

The City of St. Joseph, Missouri, established an ordinance that requires manufactured home communities to provide storm safe rooms for their residents. All storm safe rooms are required to meet local Americans with Disabilities Act requirements and the design criteria set forth by FEMA 361, Design and Construction Guidance for Community Shelters. For details, contact the City of St. Joseph Building Codes Department.

Kansas City Area Northland Habitat for Humanity Safe room Initiative

The Habitat for Humanity Northland coordinated the construction of safe rooms in 10 of their homes. All safe rooms were constructed to meet criteria set forth by FEMA 320, Taking Shelter From the Storm: Building a Safe room Inside Your House. For details on the Habitat for Humanity safe room projects, contact your local Habitat for Humanity chapter.

Additional Projects

Listed below are more examples of the types of mitigation projects that have been undertaken by communities throughout the State. These projects were cost-effective based on the FEMA benefit-cost analysis module, and they provided a benefit to their communities by decreasing the impact of related disasters.

City of Richmond—Drop box installation ($2,434), to alleviate flooding caused by stormwater runoff, which exceeded capacity of old drainage system.

Moniteau County—Culvert replacement at four locations ($8,731), to replace and upgrade culverts at four locations.

Platte County—Culvert upgrade at two locations ($20,371), to upgrade culverts where capacity was not sufficient to handle run off from heavy rain events.

Platte County—Sewer upgrade ($11,927), to replace storm sewer in residential area, which was no longer collecting stormwater.

City of Blue Springs—Sewer upgrade ($177,455), to increase capacity of sanitary sewer system in residential area, which would overflow during heavy rain events.

City of Grain Valley—Culvert upgrade ($91,000), to increase capacity of stormwater culvert in residential area, which would overflow during heavy rain events.

City of Grain Valley—Manhole repairs ($32,979), to clean, repair, and seal 48 manholes to prevent infiltration of stormwater into the sanitary sewer system.

City of Lee's Summit—Sewer upgrade ($669,000), to increase capacity of sanitary sewer system in residential area, which would overflow during heavy rain events.

City of Greenwood—Sewer upgrade ($288,233), to replace existing storm sewer system in residential area, which had deteriorated to 10 percent of capacity.

City of Savannah—Sewer improvements ($336,837), to install improved drainage system in commercial and residential area, which overflowed during heavy rain events.

7.6 Commitment to a Comprehensive Mitigation Program

Requirement §201.5(b)(4)(i-vi):	The enhanced plan must demonstrate that the state is committed to a comprehensive state mitigation program, which might include any of the following: • A commitment to support local mitigation planning by providing workshops and training, state planning grants, or coordinated capability development of local officials, including emergency management and floodplain management certifications. • A statewide program of hazard mitigation through the development of legislative initiatives, mitigation councils, formation of public/private partnerships, and /or other executive actions that promote hazard mitigation. • The state provides a portion of the nonfederal match for HMGP and/or other mitigation projects. • To the extent allowed by state law, the state requires or encourages local governments to use a current version of a nationally applicable model building code or standard that addresses natural hazards as a basis for design and construction of state sponsored mitigation projects. • A comprehensive, multiyear plan to mitigate the risks posed to the existing buildings that have been identified as necessary for post-disaster response and recovery operations. • A comprehensive description of how the state integrates mitigation into its post-disaster recovery operations.

Throughout this plan SEMA and State mitigation planning partners have documented their commitment to a comprehensive mitigation program. The State's desire is for this plan to be a resource to other planning partners. The embedded hyperlinks allow the user to easily access additional information through other websites or data gathered during plan development.

Support for Local Mitigation Planning

Training

The State has demonstrated its commitment to support local mitigation planning throughout this plan. Section 7.1.2 of this Chapter provides details of workshops and training for local officials for floodplain management certification, local mitigation planning, hazard mitigation grants, and benefit cost-analysis. The Missouri Certified Emergency Manager Program (MoCEM) is sponsored and administered by the Missouri Emergency Preparedness Association (MEPA) with cooperation and support of the State Emergency Management Agency (SEMA). See here for more information

Hazus Flood Risk Data Available

The State is pleased to provide online access to the Hazus flood risk results for all 115 counties in the State (including the independent City of St. Louis). Local planners or other interested parties can obtain

Hazus flood layers as well as produced PDF Hazus flood maps to assist in local decision-making. All local Hazus products are available through SEMA.

Staff Member Dedicated to Local Planning Assistance

Since 2007, SEMA has maintained a contracted position that is dedicated to assisting local governments with mitigation planning efforts.

Legislative Initiatives, Mitigation Councils, Public/Private Partnerships, Executive Actions

The State of Missouri has demonstrated the use of legislative initiatives, mitigation councils, public/private partnerships, and executive actions in implementing the State's Mitigation Strategy. Below are a few highlights:

- State Statute RSMO 310.200-207 is one example of the State's commitment to mitigation. This statute applies to 47 southeast counties in Missouri that are required to adopt an ordinance requiring new public construction/alteration to comply with seismic design and construction of the BOCA code or UBC.
- Executive Order 97-09 was signed by the lieutenant governor in July 1997 authorizing SEMA to issue floodplain permits for any state-owned or leased development in a special flood hazard area.
- State Hazard Mitigation Planning Team is a State mitigation Council that meets regularly to complete reviews and updates to this Mitigation Plan.
- With the Online Flood Visualization Tool, SEMA is building a bridge of communication to the private sector and others to ensure availability of accurate and timely information in a web-based application. The Online Flood Visualization Tool under development by SEMA is scheduled for release in mid-2010. It will communicate the principles of FEMA's RiskMAP strategy and will provide a clearinghouse of flood hazard information for use by developers, the insurance industry, government agencies, and the public.
- With the creation of the Flood Recovery Task Force after the 2008 flooding, the Missouri Governor emphasized the need for mitigation planning in the aftermath and recovery from devastating floods.

State Funds for Mitigation

The State of Missouri partially funds the floodplain management budget. In the past, the State of Missouri has provided funding to match mitigation assistance grants. However, this funding has not been available for the past three years due to budget constraints.

Building Design and Construction

For State-sponsored mitigation projects, SEMA requires sub-applicants to adhere to all applicable building code requirements. In addition, for safe room construction projects, SEMA requires adherence to FEMA's Design and Construction Guidance. As indicated previously, all public buildings constructed in the 47 southeastern counties designated as earthquake-prone are required to be constructed in accordance with seismic design and construction.

Comprehensive State Mitigation Program

The overall effectiveness of the State's mitigation program is demonstrated in Section 7.5 Effective Use of Available Mitigation Funding and in Section 7.3 Program Management Capability.

Missouri has been in the forefront in mitigation nationally, demonstrated by being one of the first States to develop a FEMA approved 'enhanced' State mitigation plan in 2004. In 2004, the plan demonstrated a commitment to address the "data limitation" noted in the risk assessment and hazard analysis and the lack of approved local hazard mitigation plans through the establishment of mitigation action category M1—State and Local Hazard Mitigation Plans. In 2010, SEMA has documented how the State continues that commitment. As of February 2010, 79 of 115 Missouri counties (including St. Louis City), which altogether accounts for 94 percent of Missouri's population, had hazard mitigation plans that met the requirements of the Disaster Mitigation Act of 2000.

Demonstration of Missouri's commitment to mitigation is integrated into each section of this plan, and represented in this plan as a whole. Some examples of the evidence of the State's commitment to mitigation can be referenced in:

- Section 2.1.1 Evolution of the State Hazard Mitigation Plan and Section 4.2 State Capability Assessment for organizations within the State that have consistently promoted mitigation:
  - Governor's Task Force on Flood Plain Management
  - Long-Term Recovery and Unmet Needs Groups
  - Structural Assessment and Visual Evaluation Coalition
  - Missouri Seismic Safety Commission
  - Regional Planning Commissions/Councils of Government
  - State Hazard Mitigation Planning Team (formerly the Hazard Mitigation Project Coordinating Group)

- Section 3.5 Assessing Vulnerability and Estimating Potential Losses by Jurisdiction for a demonstration of additional commitment in vulnerability assessment. Missouri is one of the few states to have completed countywide Hazus flood and earthquake loss estimations for every county in the State. The addition in this 2010 plan update of integrated DFIRM depth grids for 28 counties provides additional evidence of Missouri's commitment to increasing accuracy of the risk assessment through available data. In addition, with this 2010 update, the State has provided a statewide risk assessment for all 20 hazards profiled in the plan.

- Chapter 4 Comprehensive State Hazard Mitigation Program for an outline of the mitigation objectives identified to raise the level of mitigation commitment:
  - Objective 1.3—Supports the development of sensible enabling legislation, programs, and capabilities of federal, state, and local governments and public-private partnerships engaged in mitigation activities
  - Objective 2.5—Encourages federal, state, and local officials; educational institutions; private associations; and private business entities that provide essential services to incorporate mitigation into other plans
  - Objective 3.2—Strengthens cooperation with SEMA's mitigation partners and helps educate them about mitigating the loss of property
  - Objective 4.2—Considers sustainability issues (ecologically sound, economically viable, socially just, and humane) when developing or reviewing mitigation projects and plans

- Chapter 5 Coordination of Local Mitigation Planning provides evidence of Missouri's commitment to the local mitigation planning efforts. In this chapter, the Sate provides specific methodology for locals to employ to determine vulnerability to dam and levee failure.

SEMA's true commitment to a comprehensive State mitigation program may be best demonstrated through the agency's efforts to meet the Emergency Management Accreditation Program (EMAP) standards. The fact that SEMA has worked diligently to meet the EMAP standards and was fully accredited on November 17, in 2007 (1 of only 16 states) is testimony to the importance that SEMA places on mitigation (and emergency management, in general). Mitigation and state mitigation planning programs are critical elements of the EMAP standard for mitigation. Section 4.4 Mitigation Actions documents how the 11 EMAP mitigation criteria are met and interlaced throughout Missouri State agencies

SEMA Receives National Accreditation
Missouri One of Only 16 States Accredited

High Hazard Dams Per County

County	Dam ID	Dam Name	State Regulated	Hazard Class	Emergency Action Plan
Adair	MO10405	Burk Lake Dam	False	2	Not Required
Adair	MO11480	Denslow Lake Dam	False	2	Not Required
Adair	MO10128	Forest Lake Dam	True	2	Yes
Adair	MO10137	Garrett Lake Dam	False	2	Not Required
Adair	MO11503	Jayne Lake Dam	False	2	Not Required
Adair	MO10136	Spring Lake Dam	False	1	Not Required
Andrew	MO11065	Dysart Lake Dam	False	2	Not Required
Andrew	MO12380	Happy Holler Dam	True	2	Not Required
Andrew	MO11608	Keller Lake Dam	False	1	Not Required
Andrew	MO10086	Lake La Verne Dam	False	2	Not Required
Andrew	MO10499	Lakeland Estates Lake Dam	False	2	No
Andrew	MO10038	Savannah City Reservoir Dam	False	1	Not Required
Andrew	MO11251	Schweizer Lake Dam	False	2	Not Required
Andrew	MO12089	Smith Lake Dam	False	2	Not Required
Andrew	MO10720	Thompson Lake Dam	False	2	Not Required
Atchison	MO11255	Graves Lake Dam	False	2	Not Required
Atchison	MO11038	Hall Lake Dam	False	1	Not Required
Atchison	MO11009	Lowell Pierce Dam	True	2	No
Audrain	MO12069	Azdell Lake Dam	False	2	Not Required
Audrain	MO10470	Blackmore Lake Dam	False	2	Not Required
Audrain	MO10105	C + A Lake Dam	False	2	Not Required
Audrain	MO11457	Cochran Dam	False	2	Not Required
Audrain	MO11401	Cook Lake Dam	False	2	Yes
Audrain	MO11163	Deimeke Lake Dam	False	2	Yes
Audrain	MO11154	Donaldson Lake Dam	False	2	Yes
Audrain	MO12071	Feutz Lake Dam East Lower	False	2	Not Required
Audrain	MO10521	Foree Lake Dam	False	2	Not Required

County	Dam ID	Dam Name	State Regulated	Hazard Class	Emergency Action Plan
Audrain	MO11208	Kohl Irrigation Lake-South	False	1	Yes
Audrain	MO11244	Lierheimer Lake Dam	False	2	Not Required
Audrain	MO10678	Locke Lake Dam North	False	2	Not Required
Audrain	MO10065	Missouri Power And Light Dam	False	1	Not Required
Audrain	MO10859	Norfolk Lake Dam/(Dry)	False	2	Not Required
Audrain	MO31281	Pehle Lake Dam	False	2	Not Required
Audrain	MO11408	Prater Dam North	False	2	No
Audrain	MO10860	Shellabarger Dam South	False	2	No
Audrain	MO11158	Shellabarger Lake Dam	False	2	Not Required
Audrain	MO11330	Sims Lake Dam	False	2	Not Required
Audrain	MO11469	Sudbrock Lake Dam	False	2	No
Audrain	MO10082	Teal Lake Dam	False	1	Not Required
Audrain	MO10296	Vandalia Community Lake Dam	False	2	Not Required
Audrain	MO11409	Williams Dam North Sec 18	False	2	Yes
Audrain	MO10383	Williams Dam South Sec 18	False	2	Not Required
Barton	MO50014	Clifton Mayo Dam	False	2	Not Required
Barton	MO20002	Lamar Lake Dam	False	2	Not Required
Bates	MO20005	Adrian Resevoir Dam	False	2	No
Bates	MO20047	Appleton City Lake Dam	False	2	Not Required
Bates	MO20046	Drexel Lake Dam	False	1	No
Bates	MO20444	Eastland Lake Dam	False	1	Yes
Bates	MO20767	Harmony Mission Dam	True	1	Not Required
Bates	MO20211	Hodges Lake Dam	False	2	Yes
Bates	MO20450	Shannon Circle S Ranch Lake Dam	False	2	Not Required
Bates	MO50027	Ward Lake Dam-Sect. 7	False	2	Not Required

County	Dam ID	Dam Name	State Regulated	Hazard Class	Emergency Action Plan
Benton	MO31052	Hayes,William Lake Dam	False	1	Not Required
Benton	MO30253	Jackson Keller Trust Lake Dam-North	False	2	Not Required
Benton	MO31654	Jackson+Keller Trust Lake Dam-South	False	2	Not Required
Benton	MO20458	Kyle Lake Dam	False	2	Yes
Benton	MO31709	Mirror Lake #1	False	2	Not Required
Benton	MO30153	Tatge Lake Dam-Sect 29	False	2	Yes
Bollinger	MO30628	Acuff & Ayers Lake Dam	False	2	Not Required
Bollinger	MO31371	Bollinger Lake Dam	False	2	Not Required
Bollinger	MO30077	Lake Of The Hills Dam	True	2	Not Required
Bollinger	MO31372	Lona Lou Lake Dam	False	2	
Bollinger	MO30857	Marquis Dam	False	2	Not Required
Bollinger	MO31374	Richardet Dam	False	2	Not Required
Bollinger	MO30839	Sherman Lake Dam	False	1	Not Required
Bollinger	MO31091	Taylor Bayless Dam	False	1	Not Required
Bollinger	MO30843	Whippoorwill Dam	False	2	Not Required
Bollinger	MO31062	Wright Lake Dam	False	1	Not Required
Boone	MO12374	Arrowhead Lake Dam	True	2	Not Required
Boone	MO12226	B & C Subdivision Dam	False	1	Not Required
Boone	MO10893	Boco Mo Dam	True	2	Not Required
Boone	MO11646	Callahan Creek A-1	True	2	No
Boone	MO11774	Callahan Creek C-2	True	2	Not Required
Boone	MO11058	Cedar Lake Dam	True	1	Not Required
Boone	MO12234	Claysville Lake Dam	True	2	Not Required
Boone	MO11068	Columbia Mum. Golf Course Dam	False	1	No
Boone	MO10895	Columbia Mun Golf Course Lower L. Dam	False	1	Not Required
Boone	MO11579	Country Boy Estates Lake Dam 2	True	2	Not Required

County	Dam ID	Dam Name	State Regulated	Hazard Class	Emergency Action Plan
Boone	MO11171	Country Club Of Mo Lake Dam	False	2	Yes
Boone	MO10016	County Downes Lake Dam	False	2	Not Required
Boone	MO31555	Demarco Lake Dam	False	1	Not Required
Boone	MO10976	Fairview Lake Dam	False	1	Yes
Boone	MO12212	Finger Lakes Dam South	True	2	Not Required
Boone	MO11318	Ginn Lake Dam	False	2	Not Required
Boone	MO11057	Hagan Lake Dam	False	1	Not Required
Boone	MO12215	Highlands Lake Dam	False	2	Not Required
Boone	MO12236	Highlands Lower Lake Dam	False	1	Not Required
Boone	MO12237	Highlands South Lake Dam	False	1	Not Required
Boone	MO10975	Hulen Lake East Dam	True	1	Not Required
Boone	MO10726	Hulen Lake West Dam	True	1	No
Boone	MO30880	Lake Champetra Dam	True	2	Not Required
Boone	MO10015	Lake Chateau Dam	False	1	Not Required
Boone	MO11596	Lake Cyrene Dam	False	1	Not Required
Boone	MO11584	Lewis Lake North Dam	False	2	Not Required
Boone	MO12229	Limerick Lake Dam	False	1	Not Required
Boone	MO11594	Mills Lake Dam	False	2	No
Boone	MO11597	Moon Valley Lake Dam	False	1	Not Required
Boone	MO11173	Moores Lake Dam	False	1	Not Required
Boone	MO10019	Philips Park Lake Dam	True	2	Not Required
Boone	MO11593	Rayfield Lake Dam	False	2	Not Required
Boone	MO10731	Roemer's Lake Dam	True	2	Not Required
Boone	MO11429	Scott Lake Dam	False	2	Not Required
Boone	MO11590	Seltsam Lake Dam	False	2	No
Boone	MO11598	Shady Lake Dam	False	1	Not Required
Boone	MO11205	Smith Hatchery Lake Dam	False	2	Not Required

County	Dam ID	Dam Name	State Regulated	Hazard Class	Emergency Action Plan
Boone	MO11172	Stephens Lake Dam	False	1	Not Required
Boone	MO11609	Tincher Lake North Dam	False	2	Not Required
Boone	MO10552	Turkey Farm Lake Dam	False	2	Not Required
Boone	MO11606	Univ Of Mo-R1 Dam	False	2	Not Required
Boone	MO11586	Walnut Crest Lake Dam	False	2	Not Required
Boone	MO12102	Waters Edge Estates Lake Dam	False	1	No
Boone	MO11588	Weil Lake Dam	False	2	No
Boone	MO10733	Welch Lake Dam	False	1	Not Required
Boone	MO10035	Windmiller Dam #1	False	1	Not Required
Boone	MO11675	Windmiller Dam #2	False	1	Yes
Boone	MO11603	Woodrail Lake Dam	True	1	Not Required
Buchanan	MO12290	Belcher Branch Lake Dam	True	2	Yes
Buchanan	MO11101	Dead Mans Hole Dam	False	2	Not Required
Buchanan	MO10426	Dearborn Reservoir Dam	False	2	Not Required
Buchanan	MO10053	Grant Lake Dam - South	False	2	Not Required
Buchanan	MO10526	Jones Dam	False	2	Not Required
Buchanan	MO10995	Komer Lake Dam	True	2	Yes
Buchanan	MO11241	Lake Flamingo Dam	False	2	Not Required
Buchanan	MO10525	Mcpheeters Lake Dam (Breached)	False	1	Not Required
Buchanan	MO10271	Scotty's Lake Dam	False	1	Not Required
Buchanan	MO10698	Ussary Dam	False	1	Not Required
Buchanan	MO10524	Wales Lake Dam	False	2	Not Required
Butler	MO40095	Hewlett Lake Dam	False	2	No
Butler	MO30870	Kelley Lake Dam	False	2	Yes
Butler	MO30256	Lake Lockloma Dam	False	2	Yes
Butler	MO30883	Lake Shore Acres Dam	False	2	No
Butler	MO30395	Mason Memorial Dam	False	2	Not Required

County	Dam ID	Dam Name	State Regulated	Hazard Class	Emergency Action Plan
Butler	MO31168	Oak Brier Estates Dam	False	2	No
Butler	MO11791	Resnik Lake Dam	False	2	Not Required
Butler	MO40077	Rolling Hills Estates Lake Dam	False	1	No
Butler	MO31164	Tomaro Oaks Dam	False	2	No
Caldwell	MO10645	City Of Breckenridge Dam	False	2	Not Required
Caldwell	MO10261	Hamilton City Water Plant Dam	True	2	Yes
Caldwell	MO11238	Hicks Lake Dam	False	2	Not Required
Caldwell	MO40181	Little Otter Creek Lo-1 Lake Dam	True	2	Not Required
Caldwell	MO12028	Mann Lake Dam	False	2	Not Required
Caldwell	MO11012	Simmons Lake Dam	False	2	
Callaway	MO10880	Althiser Lake Dam	False	2	Yes
Callaway	MO11312	American Cent Corp Upper Dam	False	2	Not Required
Callaway	MO12213	Bass Lake Dam	False	2	Not Required
Callaway	MO10883	Baumgartner Dam	False	1	Not Required
Callaway	MO12278	Baumgartner Lake Dam	True	2	Not Required
Callaway	MO31461	Covington Lake Dam	False	2	No
Callaway	MO10245	Eve Lake Dam	False	2	No
Callaway	MO10062	Forest Lake Dam	True	2	Not Required
Callaway	MO10074	G&G Cattle Co Dam East	False	2	Not Required
Callaway	MO10031	G7g Cattle Co Dam West	False	2	Not Required
Callaway	MO30009	Gurwit&Lewis Lake Dam	False	2	No
Callaway	MO10990	Guthrie Lake Dam	False	1	Not Required
Callaway	MO10989	Hauck Lake Dam	False	1	Not Required
Callaway	MO30915	Henke Lake Dam	False	2	No
Callaway	MO10739	Hrin Lake Dam	False	2	Not Required
Callaway	MO11526	Junior Lake Dam	False	1	Not Required
Callaway	MO11048	Katy Lake Dam	True	2	Not Required
Callaway	MO10886	Lac Piete Dam	False	1	Not Required

County	Dam ID	Dam Name	State Regulated	Hazard Class	Emergency Action Plan
Callaway	MO31276	Lake Lahweeno Dam	True	2	Yes
Callaway	MO10912	Lehenbauer Lake Dam-Sect 35	False	2	Not Required
Callaway	MO10888	Little Dixie Dam	True	1	Not Required
Callaway	MO31274	Lower Canyon Lake Dam	True	2	Not Required
Callaway	MO10293	Meadow Brook Dam	False	2	Not Required
Callaway	MO10881	Reeds Lake Dam	False	2	Not Required
Callaway	MO11195	Renner Dam	False	2	Not Required
Callaway	MO30323	Trimble Lake Dam-West (Dry)	False	2	Not Required
Callaway	MO10023	Vaughn Dam	False	2	Not Required
Callaway	MO10876	Whetstone Creek Wildlife Dam	True	2	Not Required
Camden	MO31610	Burton Duenke #1 Dam	True	2	Not Required
Camden	MO31611	Burton Duenke #2 Dam	True	2	Not Required
Camden	MO31609	Burton Duenke #3 Dam	True	2	Not Required
Camden	MO31713	Burton Duenke #4 Dam	True	1	No
Camden	MO31608	Burton Duenke #5 Dam	True	2	Not Required
Camden	MO40180	Hidden Lakes #5	True	2	Not Required
Camden	MO31923	Marschke Lake Dam	False	2	Not Required
Camden	MO31937	Seasons Ridge Golf Course Dam	True	1	Not Required
Camden	MO31606	Treeline Lake Dam	True	1	Not Required
Camden	MO31110	Turner Lake Dam	True	2	No
Cape Girardeau	MO30211	Bella Vista Dam	True	2	No
Cape Girardeau	MO31223	Brown Lake Dam	False	1	No
Cape Girardeau	MO40109	City Of Cape Girardeau Dam	True	1	No
Cape Girardeau	MO31218	Garms Lake Dam	False	1	Not Required
Cape Girardeau	MO40008	Lake Boutin Dam	True	1	

County	Dam ID	Dam Name	State Regulated	Hazard Class	Emergency Action Plan
Cape Girardeau	MO30066	Lake Girardeau Dam	True	2	Not Required
Cape Girardeau	MO40050	Lake Hollenbeck Dam	True	1	Not Required
Cape Girardeau	MO31225	Lake Tanglewood North Dam	False	1	No
Cape Girardeau	MO31224	Lake Tanglewood South Dam	False	1	No
Cape Girardeau	MO30214	Lipps Lake Dam	True	2	Not Required
Cape Girardeau	MO30533	Little Bear Lake Dam	False	1	Not Required
Cape Girardeau	MO30950	North Hills Estate Surbd Lake Dam	False	2	No
Cape Girardeau	MO31216	North Twin Lakes Dam	False	1	No
Cape Girardeau	MO30973	Pemberton Lake Dam-Sec 22	False	2	
Cape Girardeau	MO31180	Spring Lake Dam	False	1	Not Required
Cape Girardeau	MO30213	Stallings Bros Dam	False	2	Not Required
Carroll	MO11814	Amery Lake Dam	False	2	Not Required
Carroll	MO10562	Anderson Lake Dam	False	2	No
Carroll	MO50809	Big Creek-Hurricane Creek S- 12	False	2	Not Required
Carroll	MO10648	Carrollton Recreation Lake Dam	False	2	Yes
Carroll	MO11681	Henry Lake Dam	False	2	Not Required
Carroll	MO10650	Johnson Lake Dam	False	1	Not Required
Carroll	MO10013	Mandeville Lake Dam	False	2	Yes
Carter	MO40193	Ed Baker Lake Dam	True	2	Yes
Carter	MO31413	Hill And Dale Dam East	False	2	Not Required
Carter	MO31715	Hill And Dale Dam West	False	2	Not Required
Carter	MO31418	Lake Hogan Dam	False	2	No
Carter	MO30353	Lakeview Tree Farm Dam	False	2	Not Required
Carter	MO31263	Wallace Lake Dam	False	1	No

County	Dam ID	Dam Name	State Regulated	Hazard Class	Emergency Action Plan
Cass	MO20230	Baiers Den Lake Dam	False	2	Not Required
Cass	MO20314	City Lake Dam	False	1	Not Required
Cass	MO20379	Haake Lake Dam	False	1	Not Required
Cass	MO20053	Harper Lake Dam	False	2	Not Required
Cass	MO20077	Harrisonville City Lake Dam	True	1	Not Required
Cass	MO20308	Heine Lake Dam	False	2	Not Required
Cass	MO20435	Ivy Wall Lake Dam	False	2	Not Required
Cass	MO31075	Jm Kircher Dam	False	1	No
Cass	MO31074	Kircher P D Dam	False	1	Yes
Cass	MO20231	Lake Annette Dam	False	2	Not Required
Cass	MO20076	Lake Luna Dam	False	1	Not Required
Cass	MO20312	Lake Winnebago Dam	True	1	Yes
Cass	MO40164	Lake Winnebago Dam Expansion	False	1	Not Required
Cass	MO20309	Loch Leonard Dam	False	1	Not Required
Cass	MO20381	May Lake Dam	False	2	Not Required
Cass	MO20776	Mill Creek Dam	True	1	Yes
Cass	MO20376	Neff Lake Dam	False	1	Not Required
Cass	MO20305	Peculiar City Resevoir Dam	False	2	No
Cass	MO20004	Pleasant Hill Lake Dam	False	2	Not Required
Cass	MO20388	Raintree Lake Dam	True	1	Yes
Cass	MO20778	Robinson Lake Dam	False	2	Not Required
Cass	MO20434	Roth Farms Lake Dam	False	1	Not Required
Cass	MO20588	Roth Lake Dam	False	2	No
Cass	MO20321	Schrock Lake Dam	False	2	Not Required
Cass	MO20322	Shingleton Lake Dam	False	2	Not Required
Cass	MO20051	Silverlake Enterprizes Lake Dam	False	2	Not Required
Cass	MO20316	Spring Lake Dam	False	2	No

County	Dam ID	Dam Name	State Regulated	Hazard Class	Emergency Action Plan
Cass	MO20238	Springdale Lake	False	1	Not Required
Cass	MO20320	Twin Pines Country Club Lake Dam	False	2	Not Required
Cass	MO20410	Uhlmann Lake Dam	False	2	Not Required
Cedar	MO20338	Cowan Lake Dam East	False	2	No
Chariton	MO12127	Marceline New Reservoir Dam	True	2	Not Required
Chariton	MO10569	Shepherd,Dan Dam	False	2	Not Required
Christian	MO30199	Liars Lake Dam	True	2	No
Christian	MO40174	Nalley Dam	True	2	Not Required
Clark	MO12197	Fox Valley Dam	True	1	Not Required
Clark	MO10133	Lake Of The Oaks Dam	False	2	Not Required
Clark	MO11322	Ludwick Lake Dam	False	2	Not Required
Clark	MO10009	Wyaconda City Dam	False	1	Not Required
Clay	MO10017	Allen Lake Dam	False	2	Not Required
Clay	MO10606	Bell Lake Dam	False	1	Yes
Clay	MO11256	Croat Lake Dam	False	2	Not Required
Clay	MO11051	Enloe Lake Dam	False	2	Not Required
Clay	MO10583	Great Midwest Corp -Mononame 168	False	1	Not Required
Clay	MO11024	Great Midwest Lake Dam	False	1	Yes
Clay	MO10574	H & H Lake Dam	False	2	Not Required
Clay	MO10043	Hendren Dam	False	2	Not Required
Clay	MO11021	Holly Lake Dam	True	1	Not Required
Clay	MO10025	Lake Bar H Dam	False	2	Not Required
Clay	MO12416	Meadow Lake Estates Dam	True	2	Not Required
Clay	MO11120	Moore Lake Dam	False	2	Not Required
Clay	MO10049	Morgan Lake Dam	False	2	Not Required
Clay	MO11022	Odd Fellows Home Lake	False	1	Not Required
Clay	MO10604	Proctor Lake Dam	False	2	Yes
Clay	MO10728	Structure #1 Williams Creek	False	2	Not Required

County	Dam ID	Dam Name	State Regulated	Hazard Class	Emergency Action Plan
Clay	MO10011	Watkins Mill State Park Dam	True	2	Not Required
Clay	MO11011	Winnetonka Lake Dam (Removed)	False	1	Not Required
Clinton	MO11112	Freeman Farm Number Three Dam	False	2	Not Required
Clinton	MO11113	Freeman Farm Number Two Dam	False	2	No
Clinton	MO10277	Freemans Farm Dam Number Four	False	2	Not Required
Clinton	MO11016	Lake Arrowhead Dam	True	1	Not Required
Clinton	MO10294	Lathrop Lake And Forest Club Dam	False	2	Not Required
Clinton	MO10121	Mcginness Lake Dam	False	2	Not Required
Clinton	MO10267	Plattsburg Old Reservoir Dam	False	2	Not Required
Clinton	MO10266	Six Mile Lane Lake Dam	True	2	Not Required
Clinton	MO11122	Spring Lake Dam	True	1	Not Required
Cole	MO30051	Binder Lake Dam	True	1	Not Required
Cole	MO30493	Church Farm Lake Dam (Breached)	False	2	Yes
Cole	MO31994	Dale Klosterman Lake Dam	True	1	Not Required
Cole	MO31910	Dalton Dam	True	2	Not Required
Cole	MO31309	Deer Valley Lake Dam	False	2	Not Required
Cole	MO30494	Dove Lake Dam	False	1	Yes
Cole	MO31051	Graessle-Rockers Lake Dam	False	2	Not Required
Cole	MO30322	Henley Lake Dam	False	1	Not Required
Cole	MO30022	Hough Park Dam	True	1	No
Cole	MO30307	Lake Carmel Dam	True	2	No
Cole	MO31483	Lakewood Dam	False	2	Not Required
Cole	MO30495	Lubker Dam	False	2	Not Required
Cole	MO30302	Mar-Kay Lake Dam	False	2	Yes
Cole	MO32089	Miller Agricultural Dan	False	2	Not Required

County	Dam ID	Dam Name	State Regulated	Hazard Class	Emergency Action Plan
Cole	MO30340	Renns Lake Dam	False	2	Not Required
Cole	MO31766	Shadow Lake Dam	False	2	Not Required
Cole	MO31769	Spring Rock Lake Dam	False	2	Not Required
Cole	MO30226	Starr Lake Dam	False	2	Not Required
Cole	MO30341	Sunset Lake Dam (Breached)	False	1	Yes
Cole	MO30320	Turpin Lake Dam	False	2	Not Required
Cole	MO30491	Twehous Lake Dam	True	1	Not Required
Cole	MO31692	Winegar Lake Dam	False	2	No
Cole	MO40134	Young Dam	True	2	No
Cooper	MO30559	Friedrich Lake Dam	False	2	Not Required
Cooper	MO10368	Rolfling Lake Dam-Sec 36 (Dry)	False	2	Not Required
Crawford	MO30742	Ballard Lake Sect 14 Dam	False	2	Not Required
Crawford	MO30987	Big Lake Dam	False	1	No
Crawford	MO30033	Brummet Lake Dam (Dry)	True	2	Yes
Crawford	MO30588	City Park Lake Dam	True	1	Not Required
Crawford	MO30982	Cobine's Folly Dam	False	2	No
Crawford	MO31287	Durbin Lake Dam	False	2	Not Required
Crawford	MO31312	Eickhoff Lake Dam	False	2	Not Required
Crawford	MO30592	Elders Lake Dam \(Dry)	False	2	Not Required
Crawford	MO30983	Field Lake Dam	False	2	No
Crawford	MO31317	Forester Lake Dam	False	2	Yes
Crawford	MO30594	Frerichs Sect-4 Lake Dam	False	2	Yes
Crawford	MO30741	Geisz Lake Dam	False	1	Not Required
Crawford	MO31809	Green Dam	True	2	Not Required
Crawford	MO30526	Haas, R. & Heck, A. Dam	False	1	Not Required
Crawford	MO30587	Holiday Lake Dam	False	1	Not Required
Crawford	MO30985	J. Bristow Lake Dam	False	1	No
Crawford	MO31503	Jellystone Park Dam	False	2	Not Required

County	Dam ID	Dam Name	State Regulated	Hazard Class	Emergency Action Plan
Crawford	MO40149	Keeven Dam	True	2	No
Crawford	MO30035	Kemp Lake Dam	False	1	Not Required
Crawford	MO30364	Papin Lake Dam	False	2	
Crawford	MO30527	Pine Lake Dam	True	2	Not Required
Crawford	MO31229	Ploch Lake Dam	False	2	No
Crawford	MO31292	Rutz Lake Dam	False	2	Not Required
Crawford	MO30363	Stubblefield Lake Dam	False	1	Yes
Crawford	MO31301	Sutter Lake Dam	False	2	Not Required
Crawford	MO30586	Thunder Valley Farm Dam	False	2	Not Required
Dallas	MO31509	Thurman Lake Dam	False	2	No
Daviess	MO12113	Grindstone Lmc F-30	True	2	Yes
Daviess	MO11220	Grindstone-Lost-Muddy Cr Dam F-20	False	2	Yes
Daviess	MO10414	Lake Viking Dam	True	2	Not Required
Daviess	MO12378	Scott/Colby Lake Dam	True	2	Not Required
Daviess	MO10179	Woodworth Lake Dam	False	2	Not Required
Dekalb	MO10170	Cameron #3 Dam	False	1	Not Required
Dekalb	MO10042	Cameron City Reservoir #1 Dam	True	2	Not Required
Dekalb	MO10169	Cameron Reservoir #2 Dam	True	2	No
Dekalb	MO10322	Duce Lake Dam	False	2	Yes
Dekalb	MO11896	Far West Stake Rlds Church Lake Dam	False	2	No
Dekalb	MO10310	Grindstn Lost-Muddy-Cr Wshd Dam B-21	False	2	No
Dekalb	MO12201	Grindstone Lmc B-1a	True	2	Not Required
Dekalb	MO10299	Grindstone Lost-Muddy-Cr Wrsd Dm A-3	False	2	Not Required
Dekalb	MO50089	Grindstone-Lost-Muddy Creek Dam A-26	False	2	Not Required

County	Dam ID	Dam Name	State Regulated	Hazard Class	Emergency Action Plan
Dekalb	MO50104	Grindstone-Lost-Muddy Creek Dam D-34	False	2	Not Required
Dekalb	MO50105	Grindstone-Lost-Muddy Creek Dam D-42	False	2	Not Required
Dekalb	MO11247	Jestes Lake Dam	False	2	Not Required
Dekalb	MO10384	King Lake/Grindstone Lmc C-3	True	2	Not Required
Dekalb	MO12375	Maysville New City Dam	True	1	Not Required
Dekalb	MO10670	Maysville New Reservoir Dam	False	2	Not Required
Dekalb	MO10171	Pony Express Lake Dam	True	2	Not Required
Dekalb	MO12140	Redman Lake Dam	False	2	Not Required
Dent	MO30267	Arrowhead Lakes Lower Dam	False	1	Not Required
Dent	MO30070	Bass Dam	False	2	Not Required
Dent	MO31049	Bishop Dam	False	2	Not Required
Dent	MO30008	Bubbling Springs Dam	False	2	No
Dent	MO30269	Clark Lake Dam	False	2	Not Required
Dent	MO30264	Hart Development Lake Dam Sect 10	False	2	Not Required
Dent	MO30054	Indian Trail Fish Hatchery Lake Dam	False	2	Not Required
Dent	MO32034	Lake Joy Dam	True	2	No
Dent	MO30266	Lake Turner Dam	False	1	Not Required
Dent	MO30071	Lake Ziske Dam	False	1	Not Required
Dent	MO30262	Loss Lake Dam	True	2	Not Required
Dent	MO30065	Masters Dam	False	1	Not Required
Dent	MO30268	Mitchell Dam	False	1	Not Required
Dent	MO31322	Tiefenthaler Lake Dam	True	2	Yes
Douglas	MO31632	Hailey Dam	False	2	Not Required
Douglas	MO20101	Noblett Lake Dam	False	2	Not Required
Dunklin	MO40064	Hilltop Fishing Lake Dam	False	1	No

County	Dam ID	Dam Name	State Regulated	Hazard Class	Emergency Action Plan
Dunklin	MO40036	Waller Lake Dam	False	2	No
Franklin	MO30574	Abell Lake Dam	True	1	Not Required
Franklin	MO40125	Anich Dam	True	1	No
Franklin	MO30768	Ankar Lake Dam (Shallow)	False	2	Not Required
Franklin	MO31135	Anthonis,E Lake Dam	False	1	Not Required
Franklin	MO32063	Baudendistel Dam	True	1	No
Franklin	MO31495	Becker Lake Dam	False	1	No
Franklin	MO30804	Boston Lakewood Park Dam	True	2	No
Franklin	MO32091	Bridgewater Lake Dam	False	1	No
Franklin	MO31251	Brown Lake Dam	False	1	Not Required
Franklin	MO31850	Brown Lake Dam	False	2	Not Required
Franklin	MO30734	Carved Lake Dam	False	2	Not Required
Franklin	MO31932	Charles West Lake Dam	False	2	Yes
Franklin	MO30770	Crescent Lake Dam	False	2	Not Required
Franklin	MO30543	Gundaker,G Dam	False	1	Not Required
Franklin	MO31054	Hermit Hollow Lake Dam	False	1	Not Required
Franklin	MO30558	Horse Shoe Lake Dam	False	2	Not Required
Franklin	MO31745	Howell Lake Dam	False	2	Yes
Franklin	MO31033	Indian Rock Lake Dam	False	1	Yes
Franklin	MO30555	Lake Aggravation	False	2	No
Franklin	MO30557	Lake Aggravation Dam	False	1	Not Required
Franklin	MO30572	Lake Arrowhead Dam	False	1	Yes
Franklin	MO30542	Lake Serene Dam	True	1	Not Required
Franklin	MO30567	Lake St Clair Number Three Dam	False	2	Not Required
Franklin	MO30769	Lake St Clair Number Two Dam	False	2	Not Required
Franklin	MO30569	Lake St. Clair Dam	True	2	Not Required

County	Dam ID	Dam Name	State Regulated	Hazard Class	Emergency Action Plan
Franklin	MO30568	Lake Thunderbird Dam	True	2	Not Required
Franklin	MO30552	Lake Torino Dam	True	1	No
Franklin	MO30541	Las Brisas Dam	True	1	Not Required
Franklin	MO31395	Lonedell Lake Dam	True	1	Not Required
Franklin	MO31497	Long View Lake Dam	True	1	Not Required
Franklin	MO31759	Lost Valley-West-Lake Dam	False	2	Not Required
Franklin	MO30566	Lynch Lake Dam	False	1	Not Required
Franklin	MO32076	Meadow Lake Estates Dam	False	2	Not Required
Franklin	MO30547	Melody Lake Dam	True	2	Not Required
Franklin	MO31934	Mo No Name	False	2	Not Required
Franklin	MO30556	Perkins East Lower Lake Dam	False	2	No
Franklin	MO30767	Peters Lake Dam	False	2	Not Required
Franklin	MO31981	Port Hudson Lake Dam	True	2	
Franklin	MO30544	Rainbow Lake Dam	False	1	Not Required
Franklin	MO30771	Redhage Lake Dam	False	2	Not Required
Franklin	MO31048	Sellenriek Dam	False	1	Not Required
Franklin	MO31494	Sherrel Lake Dam	False	2	Not Required
Franklin	MO30570	Smith Lake Dam	False	2	Not Required
Franklin	MO30047	Stallman Lake Dam	False	2	Not Required
Franklin	MO30787	Strubberg Lake Dam	False	2	Not Required
Franklin	MO30764	Swantner Lake Dam	False	2	Not Required
Franklin	MO31077	Von Der Ahe	False	1	Yes
Franklin	MO31488	Von Derosa Number 3 Lake Dam	False	2	No
Franklin	MO30545	Whispering Valley Lake #1 Dam	True	2	Not Required
Franklin	MO30535	Whispering Valley Lake #2 Dam	True	2	No
Franklin	MO31450	Whispering Valley Lake #3	False	2	Not Required
Franklin	MO30805	Winter Lake Dam	True	2	Yes

County	Dam ID	Dam Name	State Regulated	Hazard Class	Emergency Action Plan
Franklin	MO30785	Zinsmeyer Lake Dam	False	2	Yes
Gasconade	MO30667	Benson Lake Dam	False	1	Not Required
Gasconade	MO30197	Brown Shanty Lake Dam	False	1	Yes
Gasconade	MO31570	Dr Henson Lake Dam	False	1	Not Required
Gasconade	MO31354	Gehrke Lake Dam	False	2	Not Required
Gasconade	MO30672	Gouldner Lake Dam	False	2	Not Required
Gasconade	MO31565	Jasper Lake Dam	False	2	Not Required
Gasconade	MO40128	John C. Hill Lake Dam	True	2	Not Required
Gasconade	MO31341	Kehr Lake Dam	False	2	No
Gasconade	MO30107	Lake Carawood Dam	False	2	Not Required
Gasconade	MO30110	Lake Northwoods Dam	True	2	Not Required
Gasconade	MO30762	Lake Timber Ridge Dam	True	1	Not Required
Gasconade	MO30665	Landwehr Lake Dam	False	2	Not Required
Gasconade	MO31351	Langenberg Lake Dam	False	2	No
Gasconade	MO30757	Lost Valley Lake Dam	False	2	Not Required
Gasconade	MO40144	Lost Valley Lake Dam #2	True	1	Not Required
Gasconade	MO30196	Peaceful Valley Lake Dam	True	1	Yes
Gasconade	MO31586	Schneider Lake Dam Lower	False	2	Not Required
Gasconade	MO31585	Schneider Lake Dam Upper	False	2	Not Required
Gasconade	MO30668	Seetal Lake Dam	True	1	Not Required
Gasconade	MO30109	Swiss Lake Estates Dam	True	2	Not Required
Gentry	MO10664	Curt Lee Dam	False	1	Not Required
Gentry	MO10078	King City New Reservoir Dam	False	2	Not Required
Gentry	MO10101	Limpp Lake Dam	False	2	Not Required
Gentry	MO40173	Middle Fork Water Company Dam	False	2	No

County	Dam ID	Dam Name	State Regulated	Hazard Class	Emergency Action Plan
Greene	MO20396	D&R Pipeline Construct. Co Lake Dam	False	1	Not Required
Greene	MO20036	Fellows Lake Dam	True	1	No
Greene	MO20479	Ford Lake Dam/(Shallow)	False	2	Not Required
Greene	MO31697	Hagewood Lake Dam	False	2	Not Required
Greene	MO30148	Hardeke Lake Dam	False	1	Not Required
Greene	MO20473	Hilliard Estates Lake Dam	False	1	No
Greene	MO20023	Lake Springfield Dam	True	1	Not Required
Greene	MO20395	Leo Journagan Lake Dam	False	1	No
Greene	MO20397	Mclean, Lee & Hammons, John Q Lake #3	False	1	Not Required
Greene	MO20394	Rainbow Lake Dam	True	2	Not Required
Greene	MO20035	Valley Water Mills Dam	False	1	No
Grundy	MO10364	Berry Lake Dam	False	2	Not Required
Grundy	MO11776	Goodrich Lake Dam	False	2	Not Required
Grundy	MO11771	Hanes Lake Dam	False	2	Yes
Grundy	MO11072	Herrold Lake Dam	False	2	Not Required
Grundy	MO11069	Mack&Woodard Lake Dam-Sect 22	False	2	Not Required
Grundy	MO11766	Preston Lake Dam	False	2	No
Grundy	MO10365	Trenton Lake Upper Dam	False	1	No
Grundy	MO10366	Trenton Lower Lake Dam	False	1	Not Required
Harrison	MO10051	Bethany City Reservoir Dam	False	1	Not Required
Harrison	MO10071	City Of Bethany Dam	True	1	Not Required
Harrison	MO10614	Panther Creek C-2	True	2	Not Required
Harrison	MO10072	Panther Creek Wtshd Dam B-10	False	2	Not Required
Harrison	MO12370	West Fork Of Big Creek C-1 Dam	True	2	Not Required

County	Dam ID	Dam Name	State Regulated	Hazard Class	Emergency Action Plan
Henry	MO20480	Barber Lake Dam	False	2	Yes
Henry	MO20260	Dickey Lake Dam	False	2	Not Required
Henry	MO20162	O'dell Lake Dam	False	2	Not Required
Henry	MO20161	Tebo Diversionary Impoundment Dam	False	2	Yes
Henry	MO20152	Tebo Freshwater Lake Dam	False	2	Not Required
Hickory	MO31666	Talbot Dam	False	2	Not Required
Holt	MO11252	Browning Lake Dam	False	2	No
Holt	MO11029	Frank Milne Dam (Dry)	False	2	Not Required
Holt	MO10498	Gordan Lake Dam	False	2	Not Required
Holt	MO11010	Ideker,Welton Dam	False	1	Yes
Holt	MO11972	Lescher Lake Dam	False	2	Not Required
Holt	MO10508	Limpp, Earl Lake Dam	False	1	Not Required
Holt	MO10353	Tenney-Hall Dam - Mononame 27 Dam	False	1	Not Required
Howard	MO10130	Fayette New City Lake Dam	False	1	Not Required
Howard	MO10131	Fayette Old City Lake Dam	False	1	Not Required
Howard	MO10385	Heyen Lake Dam	False	2	Not Required
Howard	MO10478	Johnmeyer Lake Dam	False	2	Not Required
Howard	MO40158	Lake View Acres Dam	True	2	Not Required
Howard	MO10790	New Horticulture Farm Dam	False	1	Not Required
Howard	MO10001	Reservoir Dam	False	1	Not Required
Howard	MO10370	Rogers Lake Dam	True	1	Not Required
Howell	MO30633	Brent Lake Dam	False	2	Not Required
Howell	MO31574	Grisham Lake Dam	False	1	Not Required
Howell	MO30943	Hide A Way Lake Dam	False	2	No
Howell	MO30055	Sims Valley Community Lake Dam	False	2	Not Required
Howell	MO31265	Stace Shannon Lake	False	2	Not Required

County	Dam ID	Dam Name	State Regulated	Hazard Class	Emergency Action Plan
Howell	MO30079	Stokes #2 Dam	False	2	Not Required
Howell	MO30945	Stokes Lake #1 Dam	False	2	Yes
Howell	MO30078	Willow Springs Hunting Club Dam	False	1	Not Required
Iron	MO30216	Asarco Lake Dam	True	2	Not Required
Iron	MO30219	Clearwater Lake Dam	False	2	Not Required
Iron	MO31988	Isp Minerals Dam	False	2	Yes
Iron	MO32037	Isp Minerals Primary Dam	True	2	No
Iron	MO30012	Lake Killarney Dam	False	1	Yes
Iron	MO31717	Lawless Lake Dam	False	1	Not Required
Iron	MO30917	Magmont Tailings Dam	True	1	Not Required
Iron	MO31231	New Viburnum Tailings Dam	True	1	Not Required
Iron	MO30342	Old Viburnum Tailings Dam #1	True	1	Not Required
Iron	MO31015	Queen Mary Dam	True	2	Not Required
Iron	MO31917	Rainbow Club Farm Dam	False	1	Not Required
Iron	MO31045	Schultz Lake Dam	False	2	Not Required
Iron	MO31043	Scott Lake Dam	False	2	Yes
Iron	MO30324	Shepard Mountain Dam	False	1	Not Required
Iron	MO30337	Snow Hollow Lake Dam	True	2	Not Required
Iron	MO31017	Viburnum City Lake Dam	True	2	Not Required
Iron	MO31016	Viburnum Tailings Dam #5	False	2	Not Required
Iron	MO30619	Walnut Hollow Lake Dam	False	1	No
Iron	MO30620	Walnut Hollow Lake Dam Sec 2-Se	False	2	Not Required
Iron	MO32051	West Peak Quarry Dam #1	True	1	No
Iron	MO32052	West Peak Quarry Dam #2	True	1	No
Jackson	MO20793	Adams Dairy Parkway Dam	True	2	Not Required

County	Dam ID	Dam Name	State Regulated	Hazard Class	Emergency Action Plan
Jackson	MO20570	Barber Lake Dam	True	1	Not Required
Jackson	MO20240	Bauman Dam - Noname 381	False	1	Not Required
Jackson	MO20233	Briggs Lake Dam	False	2	Not Required
Jackson	MO20145	Christiansen Lake Dam	False	1	Yes
Jackson	MO20139	Deramus Lake Dam/Ce Report-Doramus	False	1	Not Required
Jackson	MO20803	Doutt Lake Dam	True	1	No
Jackson	MO20132	Harmon Lake Dam	False	2	No
Jackson	MO20140	Kernodle Lake Dam #1	False	1	Not Required
Jackson	MO20374	Kernodle Lake Dam #2	False	1	Not Required
Jackson	MO20141	Kernodle Lake Dam Number Four	False	1	Not Required
Jackson	MO20382	Kernoodle Lake Dam Number Three	False	2	Not Required
Jackson	MO10045	Lake Jacomo Dam	True	1	Not Required
Jackson	MO20040	Lake Lotawana Dam	True	2	Not Required
Jackson	MO20127	Lake Tapawingo Dam	True	1	No
Jackson	MO20373	Lakewood-East Dam	True	1	No
Jackson	MO20242	Lakewood-West Dam	True	1	Not Required
Jackson	MO20809	Legacy Dam	False	2	Not Required
Jackson	MO20234	Lone Pine Farm Lake Dam	False	2	Not Required
Jackson	MO20012	Longview Dam - North	False	2	No
Jackson	MO20129	Mershon Lake Dam	False	2	No
Jackson	MO20437	Morris Lake Dam	False	2	No
Jackson	MO20232	Oakwood Lake Dam	False	2	Not Required
Jackson	MO20806	Paul Hayes Lake Dam	False	2	Not Required
Jackson	MO20777	Prairie Hollow Lake Dam	False	2	Not Required
Jackson	MO10044	Prairie Lee Lake Dam	True	1	Not Required

County	Dam ID	Dam Name	State Regulated	Hazard Class	Emergency Action Plan
Jackson	MO20133	Quickel Lake Dam	False	2	Not Required
Jackson	MO20032	Reed Area No 3	False	1	Not Required
Jackson	MO40116	Rosenfelt Dam	True	1	No
Jackson	MO20235	Shady Lake Dam	False	2	Not Required
Jackson	MO11907	Sibley Orchards Lake Dam	False	2	Not Required
Jackson	MO20807	Summit Mills Dam	False	2	Not Required
Jackson	MO20237	Sunny Shores Dam	False	1	Not Required
Jackson	MO20136	Tarsney Lake Dam	False	1	Not Required
Jackson	MO20167	Terrace Lake Dam	False	1	Not Required
Jackson	MO20715	Tharp Orchard Lake Dam	False	2	No
Jackson	MO20144	Tom Smith Lake - East Dam	True	1	Not Required
Jackson	MO40176	Tom Smith Lake West	True	1	
Jackson	MO40175	Tom Smith South Lake Dam	True	1	Not Required
Jackson	MO30225	Union Lake Dam	False	1	Not Required
Jackson	MO20039	Unity #1 Dam	True	1	Not Required
Jackson	MO20134	Unity #2 Dam	True	1	Not Required
Jackson	MO20146	View High Lake Dam	True	1	Not Required
Jackson	MO20128	Whispering Hills Lake Dam	True	1	No
Jackson	MO20045	Wildwood Dam	False	1	Yes
Jackson	MO20135	Wood Lake Dam	False	2	Not Required
Jasper	MO20441	Barker Lake Dam	False	2	Not Required
Jasper	MO20196	Blackberry Hay Farm Dam	False	1	Not Required
Jasper	MO20202	Elliot Lake Dam	False	2	Yes
Jasper	MO20278	Herr Lake Dam	False	2	Not Required
Jasper	MO20267	Rainey Lake Dam	False	1	Not Required
Jefferson	MO30410	Anderson Lake Dam	False	1	Not Required
Jefferson	MO31171	Atwood Lake Dam	False	1	Not Required
Jefferson	MO30446	Autumn Lake Dam	False	1	Not Required
Jefferson	MO30435	Becker Lake Dam	False	1	Not Required

County	Dam ID	Dam Name	State Regulated	Hazard Class	Emergency Action Plan
Jefferson	MO30461	Bequette Dam - Noname 262	False	1	Not Required
Jefferson	MO30398	Booth Lake Dam	False	2	Yes
Jefferson	MO31208	Boyher Lake Dam	False	2	Not Required
Jefferson	MO31966	Brian Haskins Lake Dam	False	2	Not Required
Jefferson	MO30073	Cedar Hill Lake #1 Dam	True	2	Not Required
Jefferson	MO30005	Cedar Hill Lake #2 Dam	True	2	Not Required
Jefferson	MO31020	Cedar Hill Lake No. 3 Dam	False	1	Yes
Jefferson	MO30437	Clear Lake Dam	False	1	Not Required
Jefferson	MO30440	Coles Lake Dam	True	2	No
Jefferson	MO30414	Conservation Club Lake Dam	False	1	Not Required
Jefferson	MO30462	Crystal Lake Dam	True	2	Not Required
Jefferson	MO30460	Deerwood Lake No.3 Dam	False	1	Not Required
Jefferson	MO30423	Dehner Lake Dam	False	1	Not Required
Jefferson	MO30441	Dierberg Lake Dam	False	2	Not Required
Jefferson	MO31153	Dresser No. 10 Dam	True	1	No
Jefferson	MO31422	Dresser No. 11	True	1	No
Jefferson	MO31362	Duncan Lake Dam	False	2	Not Required
Jefferson	MO30442	First Central Services Lake Dam	False	2	Not Required
Jefferson	MO31035	Fisherman's Lake Dam	False	1	Not Required
Jefferson	MO30407	Flat Rock Lake Dam	False	2	Not Required
Jefferson	MO10699	Fondulac Dam	False	1	Not Required
Jefferson	MO10700	Glen Rose Lake Dam	False	1	Not Required
Jefferson	MO30464	Glenwilfern Lake Dam	True	2	Yes
Jefferson	MO31210	Gwenmil Lake Dam	False	1	No
Jefferson	MO40150	Hawk's Point Dam	False	1	Not Required
Jefferson	MO10662	Hermitage Hills Lake Dam	False	2	No
Jefferson	MO31927	Hidden Hollow Farm Dam	False	2	Not Required

County	Dam ID	Dam Name	State Regulated	Hazard Class	Emergency Action Plan
Jefferson	MO30418	Hidden Valley Lake Dam	True	2	Not Required
Jefferson	MO30424	Hideout Lake Dam	False	1	Not Required
Jefferson	MO30406	Kinnippi Lake Dam	False	1	Not Required
Jefferson	MO31986	Kirkpatrick Lake Dam	False	2	Not Required
Jefferson	MO30455	Kostyshock Lake Dam	True	2	No
Jefferson	MO30404	Laguna Palma Dam	False	1	Not Required
Jefferson	MO30411	Lake Adelle Dam	False	1	Not Required
Jefferson	MO30430	Lake Ararat Dam	False	1	Not Required
Jefferson	MO30434	Lake Bono Del Dam	False	1	Not Required
Jefferson	MO30400	Lake Briarwood Dam	True	1	Yes
Jefferson	MO31389	Lake Forest Estates Dam	True	2	Not Required
Jefferson	MO30405	Lake George Dam	False	2	Not Required
Jefferson	MO11099	Lake Kearney Dam	False	1	Not Required
Jefferson	MO30433	Lake Lorraine Dam	True	1	Not Required
Jefferson	MO30419	Lake Maryann Dam	False	2	No
Jefferson	MO30151	Lake Montowese Dam	True	1	Yes
Jefferson	MO30368	Lake Tekakwitha Dam	False	2	Not Required
Jefferson	MO30039	Lake Tishomingo Dam	True	2	Not Required
Jefferson	MO30427	Lake Trails Dam	True	2	Not Required
Jefferson	MO30425	Lake Virginia Dam	False	1	Not Required
Jefferson	MO30080	Lake Wauwanoka Dam	True	1	Not Required
Jefferson	MO30431	Lakes Of Deerwood Number One Dam	False	2	Not Required
Jefferson	MO30432	Lakes Of Deerwood Number Two Dam	False	2	Not Required
Jefferson	MO30451	Land Of Lakes Dam	False	1	No
Jefferson	MO30369	Lembeck Lake Dam	False	1	Not Required
Jefferson	MO30428	Leonard,Glen Dam	False	1	Not Required
Jefferson	MO30445	Liguori Lake Dam - Nonane 255	False	1	No

County	Dam ID	Dam Name	State Regulated	Hazard Class	Emergency Action Plan
Jefferson	MO31204	Lindwell Lake Dam	False	2	No
Jefferson	MO30456	Little Lake Dam	False	1	Not Required
Jefferson	MO31997	Lost Trails Estates Dam	True	2	Not Required
Jefferson	MO30439	Lower Valle Mines Dam	False	1	Not Required
Jefferson	MO30454	Lucas Lake Dam	False	2	Not Required
Jefferson	MO31907	Manley Lake Dam	False	2	Yes
Jefferson	MO31889	Marshall Lake Dam	True	2	Yes
Jefferson	MO30463	Mo No Name 264	False	2	No
Jefferson	MO40140	Morse Mill Lake Dam	True	1	Not Required
Jefferson	MO30408	Paw-Paw Lake Dam	False	2	Not Required
Jefferson	MO30447	Pine Lake Dam	False	1	No
Jefferson	MO31913	Raintree Dam #2	True	1	Yes
Jefferson	MO31828	Raintree Plantation Dam	True	1	Not Required
Jefferson	MO31209	Reichmuth Lake Dam/(Shallow)	False	2	No
Jefferson	MO30420	River Cement Company Dam	True	1	Yes
Jefferson	MO30467	Rustic Hills Lake Dam	True	2	Yes
Jefferson	MO30458	Rustic Hills Resort Lake Dam	False	2	Not Required
Jefferson	MO31199	Siesta Lake Dam	False	1	Not Required
Jefferson	MO31851	Silver Lake Dam	True	2	Yes
Jefferson	MO30401	Spring Lake Dam	False	1	Yes
Jefferson	MO31193	Spring Lake Dam	True	1	No
Jefferson	MO11098	Steeger Lake Dam	False	1	Not Required
Jefferson	MO31130	Stewart Lake Dam	False	2	Not Required
Jefferson	MO31939	Stonehenge #1 Dam	True	1	Not Required
Jefferson	MO30459	Summer Set Lake Dam	True	1	Not Required
Jefferson	MO30412	Sun Fish Lake Dam	False	2	Not Required
Jefferson	MO30457	Sunrise Big Lake Dam	True	1	Not Required

County	Dam ID	Dam Name	State Regulated	Hazard Class	Emergency Action Plan
Jefferson	MO31190	Sunrise Lake Upper Dam	True	1	No
Jefferson	MO30436	Sweetwater Dam - Noname 251	False	1	Not Required
Jefferson	MO30452	Tamarack Dam	False	1	Not Required
Jefferson	MO30129	Teamsters Dam	False	2	Not Required
Jefferson	MO30448	Turn-Bo Dam	False	2	Not Required
Jefferson	MO30370	Upper Valle Mines Dam	False	1	Not Required
Jefferson	MO30438	Valle Lake Dam	True	2	Not Required
Jefferson	MO40178	Valley View Lake Dam	True	1	Not Required
Jefferson	MO30429	Vatterott Dam	True	2	Not Required
Jefferson	MO31205	Wagner Lake Dam	False	2	No
Jefferson	MO30374	Ware Lake Dam	False	2	Not Required
Jefferson	MO30449	Weber Hill Terrace Lake Dam	True	1	Not Required
Jefferson	MO30426	Wildwood Lake Dam	True	2	Not Required
Jefferson	MO30384	Williams Dam	False	1	Not Required
Jefferson	MO31192	Winter Haven Lake Dam	True	1	No
Jefferson	MO30443	Zeman Lake Dam	False	2	Yes
Johnson	MO20438	E Br S Fk Blackwtr Rvr Wrsd Dam B-19	False	2	No
Johnson	MO50228	E.Br So Fk Blackwater E-24	False	2	Not Required
Johnson	MO11853	Edmunds Lake Dam	False	2	Not Required
Johnson	MO20494	Foffel Lake Dam	False	1	Not Required
Johnson	MO20532	Holden New City Reservoir	True	1	Yes
Johnson	MO20194	Holden Reservoir Dam West	False	2	No
Johnson	MO20246	Hunter,Roberts Lake Dam	False	2	Not Required
Johnson	MO20020	Johnson # A-1 Dam	False	1	No
Johnson	MO20073	Johnson Co. # A-26 Dam	False	1	Not Required
Johnson	MO20016	Kesterson Dam	False	2	

County	Dam ID	Dam Name	State Regulated	Hazard Class	Emergency Action Plan
Johnson	MO20488	Kranz Lake Dam	False	2	Not Required
Johnson	MO20183	Lenny Lake Dam	False	2	Not Required
Johnson	MO20037	Lions Lake Dam	False	1	Not Required
Johnson	MO20430	Mccannon Lake Dam	False	2	Not Required
Johnson	MO20044	Pertle Springs Dam	False	1	
Johnson	MO20440	Rice Lake Dam	False	2	Not Required
Johnson	MO20182	Rock Island Lake Dam	False	1	Not Required
Johnson	MO40148	Rock Lake Village Dam	True	1	Not Required
Johnson	MO20033	Sexton Lake Dam	True	2	Not Required
Johnson	MO20177	Skyhaven Lake Dam	False	1	Not Required
Johnson	MO50234	South Fork Blackwater River Dam Lt-67	False	2	Not Required
Johnson	MO11851	South Lake Dam	False	2	Not Required
Johnson	MO20178	Tackett Lake Dam	False	2	Not Required
Johnson	MO20248	Warrensburg Country Club Lake Dam	False	1	Not Required
Knox	MO10110	Henry Sever Dam	True	2	Not Required
Knox	MO10145	Hurdland Severs Lake Dam	False	2	Not Required
Knox	MO10456	Schultz Lake Dam	False	2	No
Knox	MO11188	Steffan Lake Dam	False	2	Yes
Knox	MO11559	Taylor Lake Dam	False	2	Not Required
Laclede	MO30121	Capoferri Lake Dam	False	2	Not Required
Laclede	MO30168	Dunlap Lake Dam	False	2	Not Required
Laclede	MO30116	Elam Lake Dam	False	2	Yes
Laclede	MO30167	Lake Shore Estates Dam Lower	False	2	Yes
Laclede	MO30170	Lake Shore Estates Dam Upper	False	2	Yes
Laclede	MO31677	Morris Lake Dam	False	2	Not Required
Laclede	MO31678	Stohr Lake Dam	False	2	Not Required
Lafayette	MO11224	Bass Lake Dam	True	2	Not Required

County	Dam ID	Dam Name	State Regulated	Hazard Class	Emergency Action Plan
Lafayette	MO11227	Beckemeyer Lake Dam	False	2	Not Required
Lafayette	MO20706	Carter Lake Dam-Sec 25 Lower	False	2	No
Lafayette	MO20707	Carter Lake Dam-Sec 25 Upper	False	2	Not Required
Lafayette	MO20699	Carter Lake Dam-Section 10 Lower	False	2	No
Lafayette	MO10535	Coats Lake Dam	True	2	Not Required
Lafayette	MO11225	Ford Lake Dam	False	2	Yes
Lafayette	MO11836	Gash Dam	False	2	Not Required
Lafayette	MO20527	Higdon Lake Dam	False	2	Not Required
Lafayette	MO20687	Hoeppner South Lake Dam	False	2	Not Required
Lafayette	MO20525	Lady's Lake Dam	False	2	Not Required
Lafayette	MO20415	Lake Lafayette Dam	True	2	Not Required
Lafayette	MO20164	Lake Venita Dam	False	2	Not Required
Lafayette	MO12103	Little Sni-A-Bar #21	True	2	Not Required
Lafayette	MO11970	Little Sni-A-Bar #22	True	2	Not Required
Lafayette	MO11235	Little Sni-A-Bar #23	True	2	Not Required
Lafayette	MO50274	M Hoefer Lake Dam	False	2	Not Required
Lafayette	MO20068	Nuelle Lake Dam	False	2	Not Required
Lafayette	MO20042	Odessa City Lake Dam	True	2	
Lafayette	MO10534	Odessa Hills Lake Dam	False	2	Not Required
Lafayette	MO20711	Petsch Dam/(Breached)	False	2	No
Lafayette	MO20426	Rauch Dam	False	2	Not Required
Lafayette	MO20504	Schuette Lake Dam	False	2	Not Required
Lafayette	MO20524	Sidha Farms Lake Dam	False	2	Not Required
Lafayette	MO11841	Tabo Creek Watershed Site A-32 Dam	False	2	Yes
Lafayette	MO20695	Tabo Creek Wtrshd Structure C-29	False	2	Not Required
Lafayette	MO10284	Wellington Nap C-21	True	2	Not Required

County	Dam ID	Dam Name	State Regulated	Hazard Class	Emergency Action Plan
Lafayette	MO11228	Wellington Nap C-22	True	2	Not Required
Lafayette	MO10283	Wellington Nap C-23	True	2	Not Required
Lafayette	MO12000	Wellington Nap D-21a	True	2	Not Required
Lafayette	MO10282	Wellington-Nap Wtrshd F-21 Dam	True	2	Not Required
Lewis	MO11333	Buck-Doe Run Watershed Structure #27a	False	2	No
Lewis	MO10349	City Of Lewistown Dam	False	2	Not Required
Lewis	MO10109	Deer Ridge Community Lake Dam	True	2	Not Required
Lewis	MO50299	Durgens Creek Watershed Dam 7	False	2	Yes
Lewis	MO10218	Ewing Lake Dam	True	2	No
Lewis	MO11293	Klocke Lake Dam	False	2	Not Required
Lewis	MO10372	La Belle Old City Lake Dam	True	2	Not Required
Lincoln	MO11309	Clarence Cannon #15	True	2	Not Required
Lincoln	MO10974	Crystal Lake Dam	False	2	Not Required
Lincoln	MO10951	Emert Lake Dam	False	2	Not Required
Lincoln	MO10896	Genteman Lake Dam	False	2	Not Required
Lincoln	MO10213	Gentry Lake Dam	False	1	Not Required
Lincoln	MO11045	Hillside Gardens Lake Dam	False	2	Not Required
Lincoln	MO10215	Lake Lincoln Dam	True	1	Not Required
Lincoln	MO50335	Lost Cr Pilot Watershed Dam F-4	False	1	Yes
Lincoln	MO10212	Lost Creek #1	True	2	Not Required
Lincoln	MO10216	Lost Creek #2	True	1	Not Required
Lincoln	MO11392	Lost Creek Watershed Site F-2 Dam	False	2	No
Lincoln	MO10972	Lost Creek Wtrshd Strctr E-7 Dam	False	2	Not Required

County	Dam ID	Dam Name	State Regulated	Hazard Class	Emergency Action Plan
Lincoln	MO10922	Luecke Lake Dam	False	2	Not Required
Lincoln	MO10945	Merenaught Farms Lake Dam	False	2	Not Required
Lincoln	MO10962	Moore Lake Dam	False	2	Not Required
Lincoln	MO10957	Palmer Farms Lake Dam	False	2	Not Required
Lincoln	MO10963	Reliable Chemical Company Lake Dam	False	2	Not Required
Lincoln	MO10771	Spring Branch Farm Lake Dam	False	2	Not Required
Lincoln	MO11264	Suter Lake Dam	False	2	
Lincoln	MO10767	Trojan Lake Dam	False	1	Yes
Lincoln	MO12220	White Lake Dam	True	1	Not Required
Lincoln	MO11286	White Memorial Area Sec-16 Lake Dam	False	2	Not Required
Lincoln	MO11125	Woodlake Dam	False	2	Not Required
Linn	MO10181	Brookfield Dam	True	1	Not Required
Linn	MO10183	Brookfield Reservoir Dam	False	2	Not Required
Linn	MO10056	Bucklin City Lake Dam	False	2	Not Required
Linn	MO10437	Linneus Lake Dam	False	2	Not Required
Linn	MO10119	Marceline City Reservoir Dam	False	2	Not Required
Linn	MO10765	Santa Fe Country Club	False	1	Not Required
Linn	MO11078	Tarpening Lake Dam	False	2	No
Linn	MO11079	Tarpening Lake Dam South West	False	2	Not Required
Livingston	MO12351	Chillicothe Flood Prevention Dam	False	1	Not Required
Livingston	MO11061	Demitt Lake Dam	False	2	No
Livingston	MO11505	Fender Farms Lake Dam North	False	2	No
Livingston	MO11798	Gilliland Lake Dam South	False	2	Yes
Livingston	MO11702	Hamilton Lake Dam East	False	2	Yes
Livingston	MO12221	Indian Creek Community Dam	True	1	Not Required

County	Dam ID	Dam Name	State Regulated	Hazard Class	Emergency Action Plan
Livingston	MO11801	Johnson Lake Dam	False	2	Not Required
Livingston	MO11794	Jones Lake Dam	False	2	Not Required
Livingston	MO12381	Lake Louise Dam	True	2	Not Required
Livingston	MO11707	Litton Lake Dam North	False	2	Yes
Livingston	MO11698	Litton Lake Dam South	False	2	Not Required
Livingston	MO10408	Olenhouse Lake Dam	False	2	Not Required
Livingston	MO11803	Paul Jones Lake Dam	False	2	Not Required
Livingston	MO11781	Reeter Lake Dam	False	2	Not Required
Livingston	MO10636	Rinehart Lake Dam	False	2	No
Livingston	MO11103	Trager Lake Dam East	False	2	Not Required
Livingston	MO10436	Watkin Lake Dam	False	2	Not Required
Macon	MO12411	Blomberg Farm Dam	True	1	Not Required
Macon	MO40141	Ed's Lake A Dam	True	2	No
Macon	MO40169	Ed's Lake B Dam	True	2	No
Macon	MO10055	Ethel Lake Dam	True	2	Not Required
Macon	MO10153	Macon Lake Dam	True	2	No
Macon	MO10387	New Cambria Lake Dam	False	1	Not Required
Macon	MO10327	Temple Stephens Co Dam	False	2	Not Required
Madison	MO31080	Anschutz Upstream Dam	False	1	Yes
Madison	MO30614	Britton Lake Dam	False	2	Not Required
Madison	MO30486	Deer Run Lake Dam	True	2	Not Required
Madison	MO30615	Doll Lake Dam	False	2	Not Required
Madison	MO30489	Fredericktown City Dam	False	1	Not Required
Madison	MO31417	John Bollinger No. 1 Dam	False	1	Not Required
Madison	MO31433	John Bollinger No. 2 Dam	False	1	Not Required
Madison	MO30612	Lake Harmony Dam	False	1	Not Required

County	Dam ID	Dam Name	State Regulated	Hazard Class	Emergency Action Plan
Madison	MO31079	Lost Valley Lake Dam	True	2	Not Required
Madison	MO31082	Madison Mine Main Dam	True	1	Not Required
Madison	MO30289	Mine Lamotte Dam	False	1	Not Required
Madison	MO31212	Neville Dam	False	2	Not Required
Madison	MO30488	Newman Lake Dam	False	1	No
Madison	MO30064	Nims Lake Dam	True	2	Not Required
Madison	MO30127	Pogue Lake Dam	False	1	Yes
Madison	MO30617	Silver Mines Lake Resort Dam	False	2	Not Required
Madison	MO31386	Skaggs Lake Dam	True	2	No
Madison	MO30611	Slime Pond Dam	False	1	Not Required
Madison	MO30613	Smitty's Catfish Pond Dam	False	1	No
Madison	MO40114	Trace Creek Dam	False	2	Not Required
Madison	MO30126	Whitehurst Lake Dam	False	2	Not Required
Maries	MO30180	Bowman Lake Dam	False	2	Not Required
Maries	MO30061	Danube Corporation Lower Dam	False	2	Yes
Maries	MO32065	Dudenhoeffer Dam	True	2	Not Required
Maries	MO32039	Lake Maxwell Dam	True	2	No
Maries	MO30173	Murphey Lake Dam	False	2	Not Required
Marion	MO11353	Frankenbach Bros Lake Dam	False	2	Not Required
Marion	MO10259	Russel Sandifer Dam	False	1	Not Required
Marion	MO10107	Stevens Lake Dam	False	2	Not Required
Marion	MO11283	Sutter Dam	False	2	Not Required
Mcdonald	MO20510	Southwest City Structure E-1	False	1	Not Required
Mercer	MO10472	Berndt Lake Dam	True	2	No
Mercer	MO11737	Berndt Lake Dam-Nese,Sec 25	False	2	Not Required
Mercer	MO11739	Berndt Lake Dam-Swsw,Sec 30	False	2	Not Required
Mercer	MO10665	Hidden Valley Lake Dam	False	1	Not Required

County	Dam ID	Dam Name	State Regulated	Hazard Class	Emergency Action Plan
Mercer	MO11070	Kelly Enterprises Lake Dam	False	2	Not Required
Mercer	MO10154	Lake Marie Dam	True	1	No
Mercer	MO10108	Lake Paho Dam	True	2	Not Required
Mercer	MO10476	Twin Lake Dam	True	1	Not Required
Mercer	MO12289	Yowell Lake Dam	False	2	Not Required
Miller	MO30227	Bittle Lake Dam	False	2	Not Required
Miller	MO31688	Helton Lake Dam	False	2	Not Required
Miller	MO30251	Lake Ja-Ha Dam	False	1	Not Required
Miller	MO30239	Munson Dam	False	2	Not Required
Miller	MO30250	Ortmeyer Lake Dam	False	2	Yes
Miller	MO30247	Town & Country Lake Dam	False	1	Not Required
Moniteau	MO31339	Bond Lake Dam	False	2	Yes
Moniteau	MO31763	Keane Lake Dam	False	2	Not Required
Moniteau	MO30236	Knipp Lake Dam	False	2	Not Required
Moniteau	MO31909	Lake Imhoff Dam	True	1	Not Required
Moniteau	MO31853	Manito Dam	True	2	Not Required
Moniteau	MO31691	Washburn Lake Dam	False	2	Not Required
Monroe	MO31282	Bergthold Dam	False	2	Not Required
Monroe	MO50361	Bill Dawson Irr. Res.	False	1	Not Required
Monroe	MO10058	Lake Tom Sawyer Dam	False	2	Not Required
Monroe	MO11569	Mccowan Dam	False	2	Not Required
Monroe	MO10538	Monroe City South Lake Dam	False	1	Yes
Monroe	MO50365	Roger O'bannon Irr. Res.	False	2	Yes
Montgomery	MO30376	Allgeyer Lake Dam	False	1	No
Montgomery	MO10158	Carl Dreyer Lake Dam	False	1	No
Montgomery	MO11156	Casper Lake Dam	False	2	No
Montgomery	MO10172	Cates Dam	False	1	No

County	Dam ID	Dam Name	State Regulated	Hazard Class	Emergency Action Plan
Montgomery	MO10934	Cool Valley Lake Dam	False	1	Yes
Montgomery	MO10950	Easterday Dam	False	1	Not Required
Montgomery	MO10993	Ehrlick Lake Dam	False	1	Not Required
Montgomery	MO10920	Golden Eagle Lake Dam	False	1	Not Required
Montgomery	MO11014	Golden Eagle Lake Dam -Upper	False	2	No
Montgomery	MO10916	Heron Lake Dam Upper	False	2	Not Required
Montgomery	MO40168	Houska-Vehige Dam	True	2	Not Required
Montgomery	MO30303	Kelly Lake Dam	False	2	Yes
Montgomery	MO30375	Kenny Lake Dam	False	2	Yes
Montgomery	MO40147	Landolt Dam	True	2	No
Montgomery	MO40152	Lensing Dam	True	2	Not Required
Montgomery	MO31467	Lone Rock Lake Dam	False	2	Not Required
Montgomery	MO30083	Loutre Valley Lake Dam	True	1	Not Required
Montgomery	MO30141	Munzlinger Lake Dam	False	2	Not Required
Montgomery	MO30922	Pepmiller Lake Dam	False	2	Not Required
Montgomery	MO30923	Pinnacle Lake Dam	True	1	Not Required
Montgomery	MO10984	Pointdexter Lake Dam	False	2	Not Required
Montgomery	MO11475	Roy-L Inc Dam (Breached)	False	2	Not Required
Montgomery	MO11371	Stanek Lake Dam	True	2	No
Montgomery	MO11458	Stanek Lake Dam	False	2	Not Required
Montgomery	MO30333	Sturgeon Lake Dam	False	2	No
Montgomery	MO10947	Wellsville Lake Dam	False	2	Not Required

County	Dam ID	Dam Name	State Regulated	Hazard Class	Emergency Action Plan
Montgomery	MO31560	Wohltman Lake Dam	False	2	Not Required
Montgomery	MO31504	Wyatt Lake Dam	False	2	Not Required
Montgomery	MO10593	Zander Lake Dam	False	1	Yes
Morgan	MO31346	Dennis Lake Dam	False	2	No
Morgan	MO40146	Sds Llc Dam	False	1	Not Required
Newton	MO51152	Hickory Creek Structure H- 1a	False	2	Not Required
Newton	MO51159	Hickory Creek Structure H- 2a	False	2	Not Required
Newton	MO51148	Hickory Creek Structure H- 9a	False	2	Not Required
Newton	MO51150	Hickory Creek Structure H- 10d	False	2	No
Newton	MO51149	Hickory Creek Structure H- 11	False	2	Not Required
Newton	MO20280	Lake Mintahama Dam	False	1	No
Newton	MO20219	Limberlost Dam	True	2	Yes
Newton	MO20730	Lost Creek B-2	True	1	Not Required
Newton	MO20731	Lost Creek D-1	True	2	No
Newton	MO20511	Lost Creek E-1	True	2	Not Required
Newton	MO20514	Lost Creek F-3	True	1	
Newton	MO20781	Lost Creek Watershed Site A-1	True	1	No
Newton	MO20782	Lost Creek Watershed Site C-2	True	1	Yes
Newton	MO20512	Newton County Structure F-1 Dam	False	1	Not Required
Newton	MO20513	Newton County Structure F-2 Dam	False	1	Not Required
Nodaway	MO11258	102 Riv Trib Wtrshd Strctr Lt-36	False	2	Not Required
Nodaway	MO10996	102 River C-5	True	2	Not Required
Nodaway	MO10557	George Balle Structure Dam	False	2	Yes
Nodaway	MO11263	Hannah Lake Dam	False	2	Not Required
Nodaway	MO12277	Mozingo Creek Dam	True	1	No

County	Dam ID	Dam Name	State Regulated	Hazard Class	Emergency Action Plan
Nodaway	MO10178	Nodaway Lake Dam	True	2	Not Required
Nodaway	MO11257	Parman Lake Dam	False	2	Not Required
Nodaway	MO11028	Pruitt Lake Dam	False	2	Yes
Nodaway	MO11260	Robbins Lake Dam	False	2	No
Nodaway	MO11259	Robbins Lake Dam Downstream	False	2	Yes
Oregon	MO30190	Nuwer Lake Dam	False	1	Not Required
Oregon	MO31486	S. Jones Lake Dam	False	1	Not Required
Osage	MO30038	Argyle Lake Dam	False	2	Not Required
Osage	MO31459	Baker Dam	False	2	Not Required
Osage	MO31844	Ben Branch Dam	True	1	Not Required
Osage	MO31270	Byington Lake Dam	False	1	No
Osage	MO30344	Kuper-Scott Ranch Dam	False	2	Not Required
Osage	MO30068	Lake Acres Dam	False	2	Yes
Osage	MO31337	Muenks Dam	False	2	Not Required
Osage	MO11294	Patterson Lake Dam	False	2	Not Required
Osage	MO30581	Pinnell Lake Dam	False	2	Not Required
Osage	MO30580	Rohlfing Dam - Mononame 408	False	1	No
Osage	MO31419	Welschmeyer's Dam	False	2	Not Required
Osage	MO30067	Willibrand Lake Dam	False	2	Not Required
Ozark	MO31881	D. O. Allen Dam	False	2	Not Required
Ozark	MO30327	Etuchee Dam	True	2	Not Required
Ozark	MO31673	Herd Dam	False	2	Yes
Ozark	MO31674	Mallow Lake Dam	False	2	No
Ozark	MO30352	Merrell Lake Dam	False	1	Not Required
Perry	MO30134	Colonial Acres Lake Dam	False	1	Not Required
Perry	MO31376	Eddleman Lake Dam	False	2	Not Required
Perry	MO31067	Ellis Lake Dam	False	1	No
Perry	MO31068	Hickory Hollow Lake Dam	True	2	Not Required
Perry	MO31226	Kool Breeze Ridge Dam	True	2	No

County	Dam ID	Dam Name	State Regulated	Hazard Class	Emergency Action Plan
Perry	MO30838	Lake Kah-Tan-Da Dam	True	2	Not Required
Perry	MO31099	Lake Kah-Tan-Da No.2	False	1	No
Perry	MO31071	Lake Kah-Tan-Da No.3	False	1	Yes
Perry	MO31066	Lakenan Lake Dam	False	1	Not Required
Perry	MO30133	Mach Lake Dam	False	1	Not Required
Perry	MO30807	Mallard Lake Dam	False	1	Yes
Perry	MO30809	Parker Lake Dam No. 2	False	1	Not Required
Perry	MO30037	Parker Lake No 1 Dam	False	1	Yes
Perry	MO30837	Perco Lake Dam North	False	2	Not Required
Perry	MO31198	Perco Lake Dam South	False	2	No
Perry	MO31097	Perry Co Sportsmans Club Lake Dam	False	1	Yes
Perry	MO30813	Perry County Comm. Lake Dam	True	2	Not Required
Perry	MO31098	Port Perry #2 Lake Dam	False	2	Not Required
Perry	MO30030	Port Perry Dam	True	1	Yes
Perry	MO30135	Whitewood Lake Dam	False	1	Not Required
Perry	MO40177	Zoellner Dam	True	2	Not Required
Pettis	MO31053	Daum Lake Dam	False	2	Not Required
Pettis	MO20800	Hayes Lake Dam	False	2	No
Pettis	MO20192	Hermora Lake Dam	False	2	Not Required
Pettis	MO20193	Rubydo Lake Dam	False	2	No
Pettis	MO30152	Spring Fork Lake Dam	True	1	Yes
Pettis	MO20034	Windsor Farrington Park Lake Dam	False	1	Not Required
Phelps	MO31336	Affolter Lake Dam	False	2	Yes
Phelps	MO31538	Blues Pond Dam	False	1	Yes
Phelps	MO30098	Brays Lake Dam	True	1	Not Required
Phelps	MO30257	Cardetti Lake Dam	False	2	Not Required

County	Dam ID	Dam Name	State Regulated	Hazard Class	Emergency Action Plan
Phelps	MO31546	Dennis Lake Dam	False	2	Yes
Phelps	MO31547	Knoblauch Lake Dam	False	2	Yes
Phelps	MO30097	Lake Scioto Dam	True	2	Not Required
Phelps	MO31915	Mcnulty Lake Dam	False	2	Yes
Phelps	MO30389	Scott's Pond Dam	False	2	Not Required
Phelps	MO30345	Tripoli Valley Dam	False	1	No
Phelps	MO31335	Walnut Hill Lake Dam	False	2	Not Required
Phelps	MO30090	William E. Towell Dam	True	1	Not Required
Pike	MO10231	Bibb Lake Dam	True	2	Not Required
Pike	MO10262	Bowling Green Dam #1	True	2	Not Required
Pike	MO12195	Bowling Green Dam #2	True	1	Not Required
Pike	MO50414	Evans & Wertz's Dam	False	2	Not Required
Pike	MO10276	Love Lake Dam	False	2	Not Required
Pike	MO31011	Magee Lake Dam	True	2	Not Required
Pike	MO10651	Morris W L Dam	False	2	No
Pike	MO10263	Old Bowling Green Reservoir Dam	False	2	Not Required
Pike	MO11304	Pfautch Lake Dam	False	2	Not Required
Pike	MO11124	Smith Lake Dam	False	1	Not Required
Pike	MO11300	Vera Lake Dam	False	2	Not Required
Pike	MO10551	White Lake Dam	False	2	No
Pike	MO11307	Wilhite Dam	False	2	Not Required
Pike	MO11299	Williams,Paul Dam	False	2	Not Required
Platte	MO10970	Adkison Lake Dam	False	2	Not Required
Platte	MO11246	Bell, Francis Lake Dam	False	2	No
Platte	MO11245	Breen Lake Dam	False	2	Not Required
Platte	MO11261	Folck Lake Dam	False	2	Not Required
Platte	MO32087	Forest Lake Dam	False	2	No
Platte	MO10689	Gray Lake Dam	False	2	Not Required

County	Dam ID	Dam Name	State Regulated	Hazard Class	Emergency Action Plan
Platte	MO10002	Houston Lake Dam	False	1	Not Required
Platte	MO10661	International Airport Dam	True	1	Not Required
Platte	MO10691	Lake Waukomis Dam	True	1	Yes
Platte	MO10929	Mononame791	False	1	No
Platte	MO10926	Riss Lake Dam	True	1	Yes
Platte	MO12376	Rogers Farm Dam	False	2	Not Required
Platte	MO10930	Smart Lake Dam	False	2	No
Platte	MO40112	Thousand Oaks Dam	True	1	No
Platte	MO10928	Wales Lake Dam - No Name 784	False	1	Not Required
Platte	MO10690	Weatherby Lake Dam	True	1	Not Required
Platte	MO12100	Wilson Lake Dam	False	2	No
Polk	MO30115	Mcnerney Lake Dam	False	2	Yes
Putnam	MO10007	Lake Thunderhead Dam	True	2	Not Required
Putnam	MO11096	Phantom Lake Dam	False	2	Not Required
Putnam	MO10152	Unionville Old City Lake Dam	False	2	Not Required
Ralls	MO31477	Ashbury Lake Dam	False	2	Not Required
Ralls	MO10977	Bear Creek Dam	True	1	Not Required
Ralls	MO10070	Eisele Lake Dam	False	2	Not Required
Ralls	MO11354	Fertch Lake Dam	False	2	Not Required
Ralls	MO11145	Gibson Dam	False	2	Yes
Ralls	MO10061	Lake Hannibal Dam	False	2	Not Required
Ralls	MO11185	Lake Hannibal Estates Upper Dam	False	1	Yes
Ralls	MO10675	Perry City Dam - Lower	False	1	Not Required
Ralls	MO10980	Perry City Dam No. 2	False	1	Yes
Ralls	MO31479	Thompson Lake Dam	False	2	Not Required
Ralls	MO10864	Woollen Lake Dam	False	2	Not Required
Randolph	MO11567	Anderson Lake Dam	False	2	Not Required
Randolph	MO11517	Brown Lake Dam	False	2	Not Required

County	Dam ID	Dam Name	State Regulated	Hazard Class	Emergency Action Plan
Randolph	MO11523	Helmich Lake Dam	False	2	Not Required
Randolph	MO10222	Higbee Lake Dam	False	2	Yes
Randolph	MO10787	Kelley Lake Dam (Dry)	False	2	Not Required
Randolph	MO11182	Martin Lake Dam	False	2	Yes
Randolph	MO11179	O'hara Lake Dam	False	2	Yes
Randolph	MO11207	Quinn&Fitzgerald Lake Dam	False	2	Not Required
Randolph	MO10629	Riley Lake Dam	False	2	No
Randolph	MO10004	Rothwell Lake Dam	False	1	No
Randolph	MO10639	Thomas Bros Lake Dam	False	2	Yes
Randolph	MO10134	Thomas Hill Reservoir Dam	True	1	Not Required
Randolph	MO10006	Water Works Lake Dam	False	1	Not Required
Ray	MO11236	Bisbee Lake Dam	False	2	Not Required
Ray	MO10580	Crystal Lake Dam	True	1	Not Required
Ray	MO11547	Hedges Lake Dam	True	2	Not Required
Ray	MO11237	Hidden Valley Lake Dam	True	2	Not Required
Ray	MO10581	Lake Arrowhead Dam	False	2	Not Required
Ray	MO10589	Lake Doniphan Dam-Lower	False	2	Yes
Ray	MO10147	Lawson City Lake Dam	True	1	
Ray	MO10238	Ray Co Dam C-21	False	2	Not Required
Ray	MO10233	Ray County Dam # A-27	False	2	Not Required
Ray	MO10239	Ray County Dam No.C-1	False	2	Not Required
Ray	MO10098	Ray County Lake Dam	False	2	Not Required
Ray	MO10588	Richmond Schools Dam	False	1	Yes
Ray	MO11966	Shirkey Recreation Park Lake Dam	False	2	Not Required
Ray	MO11230	Tanner Lake Dam	False	2	Not Required
Ray	MO10590	Timber Lake Dam	False	2	Yes

County	Dam ID	Dam Name	State Regulated	Hazard Class	Emergency Action Plan
Ray	MO12091	Upper Doniphan Dam	False	1	Not Required
Ray	MO50432	Wilderness Camp Lake Dam	False	1	Not Required
Ray	MO10234	Willow Creek Watershed Dam A-22	False	2	Not Required
Ray	MO11084	Willow Creek Wtrshd Site A-1	True	2	Not Required
Reynolds	MO30330	Brushy Creek Mine Water Clarification	False	1	No
Reynolds	MO30951	Brushy Creek Tailings	True	1	Not Required
Reynolds	MO40196	Brushy Creek Tailings #2	True	1	Yes
Reynolds	MO30162	Buick Tailings Dam	True	1	Not Required
Reynolds	MO31042	Firepit Lake Dam	True	1	Not Required
Reynolds	MO31141	Fletcher Mine Clarification Da	True	1	Not Required
Reynolds	MO30160	Fletcher Tailings Dam	True	1	Not Required
Reynolds	MO30164	Okkapassa Dam	False	1	Yes
Reynolds	MO30056	Roy Davis Dam	False	1	Not Required
Reynolds	MO31157	Sela Land Dam	False	1	
Reynolds	MO30166	Sweetwater Tailings Dam	True	1	Not Required
Reynolds	MO31833	Westfork Main Dam	True	1	Not Required
Reynolds	MO31832	Westfork Southeast Dam	True	1	Yes
Reynolds	MO30026	Wiggins Ozark Camp Dam	False	1	Yes
Ripley	MO31408	Fourche Creek Wtrshd No. 7	True	2	Not Required
Ripley	MO31460	Kirby Dam	False	2	Not Required
Ripley	MO31995	Lower Little Black G-2 Dam	True	2	No
Ripley	MO31938	Upper Little Black A-2	True	2	Not Required
Ripley	MO31829	Upper Little Black A-7 Dam	True	2	Not Required
Ripley	MO31899	Upper Little Black D-2	True	2	Yes

County	Dam ID	Dam Name	State Regulated	Hazard Class	Emergency Action Plan
Ripley	MO31862	Upper Little Black D-4 Dam	True	2	Yes
Ripley	MO31861	Upper Little Black D-8 Dam	True	2	Yes
Ripley	MO31978	Upper Little Black Site D-3 Dam	False	2	Not Required
Saline	MO10656	Blackburn Pond (Mononame 209)	False	1	Yes
Saline	MO10111	Only Way Lake Dam	False	2	Not Required
Saline	MO11632	Rasse Lake Dam	False	2	
Saline	MO10657	Robertson Lake Dam	False	2	No
Saline	MO10658	Van Meter Dam	True	2	Not Required
Saline	MO11634	Vogel Lake Dam	False	2	Not Required
Schuyler	MO10393	Gingerich,Ursel Dam	False	1	Not Required
Schuyler	MO10851	Lancaster City Dam	False	1	Not Required
Schuyler	MO10186	Queen City Reservoir Dam	False	2	No
Scotland	MO10981	Bear Creek Watershed B-26	False	1	Not Required
Scotland	MO10217	Memphis Lake Dam	True	1	No
Scotland	MO10163	Memphis Reservoir Dam	False	1	Yes
Scott	MO40069	Burnett Lake Dam	False	1	No
Scott	MO40070	Caney Basin Dam	True	2	No
Scott	MO40085	Davis Lake Dam	False	2	No
Scott	MO40068	Lauck Lake Dam	True	1	No
Scott	MO40006	Tywappity Community Lake Dam	True	1	Not Required
Shannon	MO40118	Coldwater Ranch Dam	False	2	No
Shannon	mo32090	Huckleberry Park Dam	False	2	No
Shannon	MO31076	Hunt Lake Dam	False	1	Not Required
Shannon	MO31064	Lake Laura Dam	True	2	Not Required
Shelby	MO10669	Buckman Dam	False	2	Not Required
Shelby	MO10608	Clarence City New Lake Dam	False	2	Yes

County	Dam ID	Dam Name	State Regulated	Hazard Class	Emergency Action Plan
Shelby	MO10609	Clarence City Old Lake	False	2	Not Required
Shelby	MO10057	Shelbina Lake Dam	False	2	Not Required
Shelby	MO10028	Shelbyville Lake Dam	False	1	Not Required
Shelby	MO10242	Wilson,David R.,Dam	False	1	Not Required
St. Charles	MO10089	August A Busch Lake #16 Dam	False	2	Not Required
St. Charles	MO10093	August A Busch Lake #51 Dam	False	2	Not Required
St. Charles	MO10095	August A Busch Lake #570 Dam	False	2	Yes
St. Charles	MO31428	Bair Lake Dam	False	2	No
St. Charles	MO30020	Bair, Jim Dam	False	2	No
St. Charles	MO10796	Beaver Lake Dam	True	1	Yes
St. Charles	MO10819	Brown's Lake Dam	False	2	Not Required
St. Charles	MO10092	Busch Wildlife #35	True	2	Not Required
St. Charles	MO10088	Busch Wildlife #37 Dam	True	2	Not Required
St. Charles	MO31845	Callaway Forks Dam	True	2	Not Required
St. Charles	MO12383	Cpc Spirit Of St. Louis Hospital Dam	False	2	Yes
St. Charles	MO31998	De Villa Trails Lake Dam	True	2	No
St. Charles	MO40167	Dierberg Dam	False	1	Not Required
St. Charles	MO31842	Essen Lake Dam	True	1	Yes
St. Charles	MO30184	Green Valley Farm	False	2	Not Required
St. Charles	MO31989	Greengate Farms Dam	True	1	Yes
St. Charles	MO11118	Hafers Lake Dam	False	1	Not Required
St. Charles	MO31429	Hinnah Lake Dam	False	2	Not Required
St. Charles	MO30293	Hoblitzelle Upper Lake Dam	False	2	
St. Charles	MO40142	Howell Dam	True	2	No
St. Charles	MO31496	Hughes Lake Dam	False	2	Not Required
St. Charles	MO11041	Incline Village Lake Dam	True	2	Not Required

County	Dam ID	Dam Name	State Regulated	Hazard Class	Emergency Action Plan
St. Charles	MO31946	Key Harbour Estate Dam #1	True	2	
St. Charles	MO31947	Key Harbour Estate Dam #2	True	2	Yes
St. Charles	MO32062	Khani Dam	True	2	No
St. Charles	MO30028	Koenig Dam	False	1	Not Required
St. Charles	MO11149	Kolb Lake Dam	False	2	Not Required
St. Charles	MO10490	Lake Sainte Louise Dam	True	1	Not Required
St. Charles	MO10545	Lake St. Louis Dam	True	1	Not Required
St. Charles	MO10494	Lawson Lake Dam	False	2	Not Required
St. Charles	MO31366	Little Lake In The Woods Dam	False	1	Not Required
St. Charles	MO32053	New Melle Quarry Dam	True	2	No
St. Charles	MO11033	Oakridge Estates Lake Dam	False	1	Not Required
St. Charles	MO10495	Park Charles South Dam	True	1	No
St. Charles	MO11117	Park Charles South No. 2	False	1	Not Required
St. Charles	MO31423	Poepsel Farm Lake Dam	False	2	Not Required
St. Charles	MO10497	Robert Schulte Dam	False	1	Not Required
St. Charles	MO30291	Sadler Lake Dam	False	2	Not Required
St. Charles	MO30294	Schultehenrich,Robert Dam	False	1	Yes
St. Charles	MO40160	Sioux Power Plant Dam	True	2	No
St. Charles	MO30631	Soloman Lake Dam	False	2	Not Required
St. Charles	MO30606	Stergen Lake Dam	True	1	Not Required
St. Charles	MO30100	Struckhoffs Lake Dam	True	2	Yes
St. Charles	MO40166	Sycamore Valley Lake Dam	True	1	Not Required
St. Charles	MO40135	Taylor Dam	False	2	Not Required
St. Charles	MO11111	The Bluffs Lake Dam	False	2	Not Required
St. Charles	MO32044	True Femme Osage Dam	True	1	No

County	Dam ID	Dam Name	State Regulated	Hazard Class	Emergency Action Plan
St. Charles	MO10643	Univ Mo Exp Farm Dam- Mononame 207	False	1	Yes
St. Charles	MO31920	Warvid Lake Dam	True	2	Yes
St. Charles	MO11119	Warwick Downs Dam	True	2	Yes
St. Charles	MO40117	Weber Dam	True	2	No
St. Clair	MO20719	Harvey Lake Dam- Sect 17	False	2	Not Required
St. Francois	MO31107	Bauman Lake Dam	False	2	Yes
St. Francois	MO31186	Bee Run Lake #1 Dam	False	2	No
St. Francois	MO31187	Bee Run Lake #2 Dam	False	2	Not Required
St. Francois	MO31188	Bee Run Lake #3 Dam	False	2	No
St. Francois	MO31046	Black Upper Lake Dam	False	2	Not Required
St. Francois	MO30903	Blackwell Pond Dam	True	1	
St. Francois	MO30157	Bonne Aqua Lake Dam	False	2	Yes
St. Francois	MO31174	Desloge Landfill Tailings Dam	False	2	Not Required
St. Francois	MO31163	Eaton Tailings Dam	True	1	No
St. Francois	MO31185	Forest Lake Dam	False	2	Not Required
St. Francois	MO30905	Goff Springs Dam	True	2	No
St. Francois	MO32032	Gruhala Lake Dam	False	2	No
St. Francois	MO31189	H&S Hill Top Lake Dam	True	2	Not Required
St. Francois	MO30150	Harman Farm Pond Dam	True	1	Not Required
St. Francois	MO31866	Harper Lake Dam	True	2	Yes
St. Francois	MO30275	Holeman Lake Dam	True	2	Not Required
St. Francois	MO30057	Iron Mountain Lake Dam	False	1	Not Required
St. Francois	MO30281	Lac Benet Dam	True	2	Not Required
St. Francois	MO30284	Lac Bourbon Dam	True	2	Not Required
St. Francois	MO31177	Lac Calista Dam	False	2	Not Required
St. Francois	MO30063	Lac Capri Dam	True	1	Not Required

County	Dam ID	Dam Name	State Regulated	Hazard Class	Emergency Action Plan
St. Francois	MO30287	Lac Carmel Dam	True	2	Not Required
St. Francois	MO30286	Lac Catalina Dam	False	1	Not Required
St. Francois	MO30283	Lac Darcie Dam	True	2	Not Required
St. Francois	MO31178	Lac Emerald Dam	False	2	No
St. Francois	MO31176	Lac Lafitte Dam	True	2	Not Required
St. Francois	MO30282	Lac Marseilles Dam	True	1	Yes
St. Francois	MO30285	Lac Michel Dam	True	2	Not Required
St. Francois	MO30339	Lac Renee Dam	True	1	Not Required
St. Francois	MO31834	Lac Veron Dam	True	2	Not Required
St. Francois	MO30313	Lake Avalon Dam	False	2	Not Required
St. Francois	MO30314	Lake Hanna Dam	True	1	No
St. Francois	MO30280	Lake Lacawanna Dam	False	1	Not Required
St. Francois	MO30904	Lake Primrose Dam	True	1	No
St. Francois	MO30156	Lake Timberline Dam	True	2	Yes
St. Francois	MO30288	Lakeview Park Dam	False	1	Not Required
St. Francois	MO30274	Leadwood Tailings Dam	True	2	Not Required
St. Francois	MO30279	Moynihan Lake Dam	False	2	Yes
St. Francois	MO30277	St. Joe State Park Dam	True	1	Not Required
St. Francois	MO30273	Sylvan Lake Dam	False	2	Yes
St. Francois	MO30276	Vineyards Twin Lakes Lower Dam	False	2	Not Required
St. Francois	MO31170	Vineyards Twin Lakes Upper Dam	False	2	Not Required
St. Francois	MO30906	Wells Lake Dam	False	1	No
St. Francois	MO31173	Welshmans Lake Dam	False	1	Not Required
St. Francois	MO31120	Yacovelli Lake Dam	False	2	Not Required
St. Louis	MO30847	Arrowhead Estates-Lower-Dam(Shallow)	False	2	Not Required
St. Louis	MO11108	Arrowhead Estates-Upper-Dam(Shallow)	False	2	Not Required
St. Louis	MO31378	Bee Tree Lake Dam	False	2	Not Required

County	Dam ID	Dam Name	State Regulated	Hazard Class	Emergency Action Plan
St. Louis	MO31393	Branneky Lake Dam	False	1	Not Required
St. Louis	MO31895	Cherry Hill Dam	True	1	Yes
St. Louis	MO32059	Chesterfield Village #2 Dam	True	1	No
St. Louis	MO32066	Chesterfield Village #3 Dam	True	1	No
St. Louis	MO40138	City Of Fenton Dam #1	False	1	Not Required
St. Louis	MO31914	City Place Dam	True	1	Yes
St. Louis	MO10489	Claymont Woods Lake Dam	False	1	Not Required
St. Louis	MO31840	Dierberg Lake Dam	True	1	Yes
St. Louis	MO10488	Fienup Lake Dam	True	1	Not Required
St. Louis	MO40194	Fountain Lake Dam	True	1	Not Required
St. Louis	MO40163	Friendship Village Dam	True	2	No
St. Louis	MO31390	General American Life Insurance Lk Dm	False	1	Yes
St. Louis	MO30852	Goessling Dam	False	1	Not Required
St. Louis	MO31137	Guilford Lake Dam	False	1	Not Required
St. Louis	MO11105	Holt's Lake Dam	False	1	No
St. Louis	MO10029	Hunter Dam	False	1	Not Required
St. Louis	MO32028	Joe Machs Lake Dam	True	1	Not Required
St. Louis	MO11277	Kehr's Mill Trail Lower Lake Dam	False	1	Yes
St. Louis	MO11636	Kehrs Mill Trails Upper Lake Dam	False	1	Yes
St. Louis	MO31134	Klein's Lake Dam	False	2	Not Required
St. Louis	MO31908	Lake Chesterfield Dam	False	2	Not Required
St. Louis	MO31136	Lake Lasalle Dam	False	2	Not Required
St. Louis	MO11278	Lake Post Commons Dam	True	2	Not Required
St. Louis	MO11017	Lake Sherwood	False	1	Not Required
St. Louis	MO31993	Lasiandra Lake Dam	True	1	No
St. Louis	MO11106	Mertz Lake Dam	False	2	Not Required

County	Dam ID	Dam Name	State Regulated	Hazard Class	Emergency Action Plan
St. Louis	MO32040	Milner Lake Dam	False	1	No
St. Louis	MO31392	Pheasant Run Lake Dam	False	2	Not Required
St. Louis	MO30848	Raewood Lake Dam	False	2	Not Required
St. Louis	MO31658	Stacy Park Resevoir Dam	False	1	Yes
St. Louis	MO30849	Strumfels Lake Dam	False	1	Not Required
St. Louis	MO32084	Village Of Green Trails Dam	False	2	Not Required
St. Louis	MO31391	Westgate Lake Dam	False	2	Not Required
St. Louis	MO12231	Wildhorse Creek Parkway Dam	True	2	Not Required
St. Louis	MO12419	Wildhorse Creek Parkway Dam #2	False	2	
St. Louis	MO31929	Woods Mill Cove Dam	True	1	Not Required
Ste. Genevieve	MO30357	Brands Lake Dam	True	2	Not Required
Ste. Genevieve	MO30356	Brands Upper Lake Dam-Sec 22	False	2	Not Required
Ste. Genevieve	MO30501	Butterfly Lake Dam	True	2	Not Required
Ste. Genevieve	MO30049	Corbin Lake Dam	False	2	Not Required
Ste. Genevieve	MO31038	Dalton Lake Dam	False	1	Not Required
Ste. Genevieve	MO30171	Donze Lake Dam	False	2	Yes
Ste. Genevieve	MO30086	Eagle Lake Dam	True	1	Not Required
Ste. Genevieve	MO30653	Foerster Dam	False	2	Not Required
Ste. Genevieve	MO31029	Giesler Lake Dam	False	2	Not Required
Ste. Genevieve	MO31382	Glen Basler Lake Dam	False	1	Not Required
Ste. Genevieve	MO31743	Goose Creek Lake Dam	True	1	Not Required
Ste. Genevieve	MO31095	Govro Dam(Shallow)	False	1	Not Required
Ste. Genevieve	MO31100	Hidden Valley Lake Dam	False	1	Yes

County	Dam ID	Dam Name	State Regulated	Hazard Class	Emergency Action Plan
Ste. Genevieve	MO31245	Kertz Farms Lake Dam	False	2	No
Ste. Genevieve	MO31383	Kisco Dam	False	2	Not Required
Ste. Genevieve	MO30087	Lake Forest Dam	True	2	No
Ste. Genevieve	MO30503	Lake Genevieve Lower Dam	False	2	Not Required
Ste. Genevieve	MO30085	Lake Heron Dam	True	1	Not Required
Ste. Genevieve	MO31039	Lake Kal-Tatri	False	1	Not Required
Ste. Genevieve	MO31916	Lake Lasata Dam	True	1	Not Required
Ste. Genevieve	MO30655	Lake Marian Dam	False	2	No
Ste. Genevieve	MO30644	Lake Minnie Ha-Ha Dam,Lower	False	1	Not Required
Ste. Genevieve	MO30643	Lake Minnie Ha-Ha Dam,Upper	False	1	No
Ste. Genevieve	MO30639	Lake Seven Falls Dam No 2	False	2	Yes
Ste. Genevieve	MO30094	Lake Seven Falls No 3	True	2	Not Required
Ste. Genevieve	MO30656	Lake Susan Dam	False	2	Not Required
Ste. Genevieve	MO31951	Mississippi Lime Lower Dam	True	1	Yes
Ste. Genevieve	MO40170	Mississippi Lime South 40 Dam	True	1	Not Required
Ste. Genevieve	MO31955	Mississippi Lime Upper Dam	True	1	No
Ste. Genevieve	MO30502	Pineview Dam	False	2	Not Required
Ste. Genevieve	MO30641	Rainbow Lake Dam	False	1	No
Ste. Genevieve	MO31859	Sagamore Lake Dam	False	1	Not Required
Ste. Genevieve	MO30640	Spring Hart Lake Dam	False	2	No
Ste. Genevieve	MO30036	Sunset Lake Dam	False	2	Not Required
Ste. Genevieve	MO31037	Sunset Lake Dam (Lake Ski Dam)	True	1	Yes

County	Dam ID	Dam Name	State Regulated	Hazard Class	Emergency Action Plan
Stoddard	MO40046	Bartlett's Fishing Lake Dam	False	1	No
Stoddard	MO32079	Dexter Noname	False	2	Not Required
Stoddard	MO40093	Duck Creek State Wildlife Refuge No 2	False	1	Yes
Stoddard	MO40094	Duck Creek State Wildlife Refuge No 3	False	1	Not Required
Stoddard	MO40063	Duck Creek-State Wildlife Refuge-# 1	False	1	Not Required
Stoddard	MO40042	Hendley Lake Dam	False	2	Not Required
Stoddard	MO40104	Lemons Gravel Dam	False	2	No
Stoddard	MO40056	Rice Lake Dam East	False	2	No
Stoddard	MO40053	Rice Lake Dam West	False	2	Not Required
Stoddard	MO50660	Richards Dam	False	1	Yes
Stoddard	MO40106	Suliman Lake Dam	False	2	Not Required
Stoddard	MO40065	Temples Lake Dam	False	1	Not Required
Stoddard	MO40034	Whites Lake Dam	False	1	Not Required
Stone	MO20509	Southwest Rc&D #1 (Crane)	True	1	Not Required
Sullivan	MO11093	Eddy's Lake Dam	False	2	Not Required
Sullivan	MO10240	Elmwood City Lake Dam	True	1	Not Required
Sullivan	MO10068	Lake Lu Juan Dam	True	2	Not Required
Sullivan	MO11076	Rusk Lake Dam	False	2	No
Sullivan	MO10503	Sears Community Lake Dam	False	2	Not Required
Taney	MO31918	Fall Creek Dam	False	1	Not Required
Taney	MO30372	Rockwood Hills Lake Dam	False	1	No
Taney	MO31846	Silver Creek Lake Dam	True	2	No
Texas	MO30074	Austin Community Lake Dam	False	2	Not Required
Texas	MO31576	Hutcheson Lake Dam	False	2	No
Texas	MO40162	James River Assembly Dam	True	2	No

County	Dam ID	Dam Name	State Regulated	Hazard Class	Emergency Action Plan
Vernon	MO20064	Hines Section 10 Lake Dam	False	2	Yes
Vernon	MO20048	Izaak Walton Lake Dam	False	2	Not Required
Vernon	MO20207	Katy Allen Lake Dam	False	1	Yes
Vernon	MO20110	Pohl-Harner Lake Dam	False	2	Yes
Vernon	MO20385	Wilson Lake Dam	False	2	Not Required
Warren	MO32058	Alpine Lake Dam	True	1	No
Warren	MO11006	Aspenhoff Lake Dam	False	1	Not Required
Warren	MO11002	B & K Lake No. 2 Dam	False	1	Not Required
Warren	MO30506	B&K Lake #1 Dam	False	1	Not Required
Warren	MO30511	Boone Trail Farm Lake Dam	False	1	Not Required
Warren	MO10759	Boulanger Lake Dam	False	2	Not Required
Warren	MO10783	Broussard Lake Dam	False	2	Not Required
Warren	MO31903	Bumb Lake #1 Dam	False	2	Not Required
Warren	MO31904	Bumb Lake Dam #2	False	2	Not Required
Warren	MO31905	Bumb Lake Dam #3	False	2	Yes
Warren	MO31906	Bumb Lake Dam #4	False	2	Not Required
Warren	MO31776	Bunge, H. Lake Dam	False	2	Not Required
Warren	MO32060	Cardinal Lake Dam	True	2	Not Required
Warren	MO30793	Castelenovo Lake Dam	True	2	Not Required
Warren	MO11075	Cedar Grove Dam	False	1	Not Required
Warren	MO10782	Cedar Knoll Farm Lake Dam	False	1	Not Required
Warren	MO11379	Deer Hollow Lake Dam	True	2	No
Warren	MO30507	Dirkemeier Lake Dam- Mononame 314	False	1	Not Required
Warren	MO10050	Dogwood Lake Dam	True	2	Not Required
Warren	MO30017	Dr. Courtney Dam	False	1	Not Required
Warren	MO10760	Dunn Lake Dam	True	2	Not Required

County	Dam ID	Dam Name	State Regulated	Hazard Class	Emergency Action Plan
Warren	MO10113	Forest Lake Dam	True	2	Not Required
Warren	MO11131	Gettinger Lake Dam	False	2	Not Required
Warren	MO11159	Hambauch Lake Dam	False	2	Not Required
Warren	MO40129	Hopewell Dam	False	2	Not Required
Warren	MO31771	Hunt Lake Dam	False	2	Not Required
Warren	MO31848	Isley Lake Dam	True	1	Not Required
Warren	MO10781	Johnson Lake Dam	False	2	Not Required
Warren	MO30515	Koepke Lake Dam North	True	2	Not Required
Warren	MO11007	Krueger Lake Dam	False	1	Yes
Warren	MO31714	Lake Aspen Dam	True	2	Not Required
Warren	MO31140	Lake Belle-Ann Dam	False	1	Yes
Warren	MO30516	Lake Grendel Dam	True	2	Not Required
Warren	MO11243	Lake Innsbrook Dam	True	2	
Warren	MO40123	Lake Kitzbuhl Dam	True	2	No
Warren	MO32048	Lake Konstanz Dam	True	2	No
Warren	MO30519	Lake Lucern Dam	False	1	Not Required
Warren	MO31442	Lake Scheffborg Dam	False	1	Not Required
Warren	MO10202	Lake Sherwood Dam	True	1	Not Required
Warren	MO31919	Lake St. Gallen Dam	True	2	Not Required
Warren	MO11132	Lake Wanderfern Dam	True	2	Not Required
Warren	MO11004	Lakeview Estates Dam	False	1	Not Required
Warren	MO30521	Lucks Lake Dam	False	2	Not Required
Warren	MO40111	Marthasville Mv-5 Dam	True	1	No
Warren	MO30508	Mcdaniels, Huelin Dam	False	1	Not Required
Warren	MO31725	Miller Lake Dam	True	2	Not Required
Warren	MO30828	Money Sunk Ranch Dam	False	2	No
Warren	MO11003	Niko Lake Dam	False	2	No
Warren	MO31294	Oetting Lake Dam	False	2	Not Required

County	Dam ID	Dam Name	State Regulated	Hazard Class	Emergency Action Plan
Warren	MO31520	Owl Creek Estates Dam #1	True	2	Not Required
Warren	MO31959	Owl Creek Estates Dam #2	True	2	Not Required
Warren	MO31960	Owl Creek Estates Dam #3	True	2	No
Warren	MO10761	Palazzo Lake Dam	False	2	Not Required
Warren	MO11000	Petersmeyer Lake Dam	False	2	Not Required
Warren	MO11001	Petersmeyer's Lower Lake Dam	False	2	Not Required
Warren	MO11700	Prior Lake Dam	False	2	Not Required
Warren	MO10033	Reid Lake Dam	True	2	No
Warren	MO31772	Rogers Lake Dam	False	1	Not Required
Warren	MO31950	Schmitt Lake Dam	False	2	No
Warren	MO10875	Scofield Lake #3 Dam	False	2	Not Required
Warren	MO31869	Seebrook Dam	True	2	Yes
Warren	MO30830	Seng Lake Dam	False	2	Not Required
Warren	MO30518	Sherman Lake Dam	False	2	Not Required
Warren	MO30520	Siegmund Lake Dam	False	1	Not Required
Warren	MO31293	Sky Ranch Lake Dam	False	1	Not Required
Warren	MO40151	Sonnenblick Lake Dam	True	1	Not Required
Warren	MO40171	Stieven Dam	True	2	Not Required
Warren	MO30522	Sugar Hollow Dam	True	1	Not Required
Warren	MO30832	Sunny Mount Church Dam	True	2	Not Required
Warren	MO31870	Trinity Lake Dam	True	2	Not Required
Warren	MO40186	Tyrol Lake Ddam	True	2	Not Required
Warren	MO31444	Vatterot Dam	False	2	No
Warren	MO12202	Village Drive Dam	True	2	Not Required
Warren	MO30059	Voelkerding Lake Dam	False	1	Yes
Warren	MO30584	White,Smith,Austin Lake Dam	False	1	Yes
Warren	MO40172	White-Boveri Dam	True	2	Not Required
Warren	MO30512	Windy Knoll Dam	False	1	Yes

County	Dam ID	Dam Name	State Regulated	Hazard Class	Emergency Action Plan
Warren	MO11005	Woodridge Lake Dam	True	1	Not Required
Warren	MO10764	Woody Creek Dam	True	1	Not Required
Washington	MO30716	Arnault Branch Mine Dam	True	2	No
Washington	MO30470	Artesian Lake Dam	False	2	Yes
Washington	MO31857	Ashley Branch Dam	True	2	Yes
Washington	MO31306	Baha Trail Lake Dam	False	2	Not Required
Washington	MO30696	Belgrade Dam	True	2	Not Required
Washington	MO30480	Bell-Settle Lake Dam	False	1	Yes
Washington	MO30729	Big Four Mine Dam	True	1	Not Required
Washington	MO31154	Black Tailings Dam	True	1	No
Washington	MO30709	Blackwell Mine Dam	True	1	Not Required
Washington	MO30478	Blue Heron Dam	True	2	Yes
Washington	MO30750	Bottom Diggins Dam	True	2	Not Required
Washington	MO30715	Cadet Mine Tailings Dam	True	2	Not Required
Washington	MO30704	Cadet No. 1 Dam	True	2	Not Required
Washington	MO30707	Cadet No. 2 Dam	True	2	Not Required
Washington	MO31830	Cadet No. 3 Dam	True	2	Yes
Washington	MO30695	Casey Lake Dam	True	2	Not Required
Washington	MO31005	Casey Lake Dam	True	1	Yes
Washington	MO31837	Crystal Lake Dam	True	2	Yes
Washington	MO31000	Davis Lake Dam	False	2	Not Required
Washington	MO30468	Desoto Mine Pit & Plant A Dam	True	2	Yes
Washington	MO30469	Desoto Pit & Plant B Dam	True	2	Yes
Washington	MO30994	Dessieux Lake Dam	False	1	Not Required
Washington	MO30726	Ditch Creek Dam	True	2	Yes
Washington	MO30731	Dorlac Lake Dam	True	2	Not Required
Washington	MO31117	Dresser #1 Dam	False	1	Yes
Washington	MO30753	Dresser Ind. Old #1	True	1	Not Required

County	Dam ID	Dam Name	State Regulated	Hazard Class	Emergency Action Plan
Washington	MO31145	Dresser Minerals #7 Dam North(Dry)	False	2	No
Washington	MO31147	Dresser Minerals #7 Dam South (Dry)	False	2	No
Washington	MO30474	Dresser No.4 Dam (Failed)	False	1	No
Washington	MO31836	Emerald Lake Dam	True	2	Not Required
Washington	MO30711	Eshbaugh-Martin Dam	True	2	
Washington	MO30744	Floyd Lake Dam	False	1	Not Required
Washington	MO31124	Flying "S" Bar Ranch Dam	True	1	No
Washington	MO30101	Forest Lake Dam	True	1	Not Required
Washington	MO30722	Four Winds Way Dam	False	2	Not Required
Washington	MO32036	Gibson Memorial Dam	True	1	No
Washington	MO30702	Gudaitis Lake Dam	False	1	Not Required
Washington	MO30476	Gun Club Lake Dam	True	2	No
Washington	MO31122	Hahn Lake Dam/(Dry)	False	2	
Washington	MO30999	Heimos Lake Dam	True	1	Not Required
Washington	MO31256	Henpeck Hollow Dam	False	1	No
Washington	MO31484	Hoffman Lake Dam	False	2	No
Washington	MO30700	Howell Mine Dam	True	2	Not Required
Washington	MO31036	Indian Creek Mine Dam - Upper	False	1	No
Washington	MO30717	Indian Creek Mine Dam-Lower	True	1	Not Required
Washington	MO32085	Johns Dam	False	2	No
Washington	MO40120	Keuss Dam	True	2	No
Washington	MO30386	Keyes Branch Mine Dam	True	1	Not Required
Washington	MO31825	King Arthur's Dam	True	2	Not Required
Washington	MO30728	Kingston No. 1 Dam	True	2	Not Required
Washington	MO31835	Lac Shayne Dam	True	2	Yes
Washington	MO30703	Lake Apache Dam	True	2	Not Required
Washington	MO30751	Lake Cherokee Dam	False	1	Not Required

County	Dam ID	Dam Name	State Regulated	Hazard Class	Emergency Action Plan
Washington	MO30688	Lakeview Dam	True	1	Not Required
Washington	MO30718	Little Indian Creek Dam	True	1	Not Required
Washington	MO31123	Lower Dresser No. 4 Dam	False	1	Not Required
Washington	MO30705	Mineral Point #1	True	1	Yes
Washington	MO31158	Mineral Point #2	True	1	Not Required
Washington	MO30727	Minnetonka Lake Dam	True	2	Not Required
Washington	MO31006	Mononame 875	False	2	Not Required
Washington	MO30708	National Lead Industries Dam	True	1	Yes
Washington	MO30706	Old Mines Tailings Dam	True	1	No
Washington	MO31118	Old Wolf Dam	True	1	Not Required
Washington	MO30482	Palmer Mine Dam	True	1	Yes
Washington	MO30483	Parole Mine Dam	True	1	Yes
Washington	MO30473	Pea Ridge Tailings Dam	True	1	Not Required
Washington	MO30992	Pine Tree Lake East Dam	False	1	No
Washington	MO30995	Pine Tree Lake West Dam	False	1	Not Required
Washington	MO31155	Pinson Gravel Company Dam	True	2	Not Required
Washington	MO30697	Podorski Lake Dam	False	2	Not Required
Washington	MO30477	Potosi Lake Dam	False	1	Yes
Washington	MO30749	Powder Spring Lake Dam	False	1	Not Required
Washington	MO30475	Racola Tailings Dam	True	2	Yes
Washington	MO31404	Richwoods Mine B Dam	True	1	Not Required
Washington	MO31849	Rogue Creek Upper Dam (Imcompleted)	False	2	Yes
Washington	MO30102	Russel Elsey Dam	False	1	Not Required
Washington	MO30112	Sayersbrook Dam	True	2	Not Required
Washington	MO31329	Schnelle Lake Dam	False	2	Yes
Washington	MO30479	Settle Mine Dam #2	True	2	Yes

County	Dam ID	Dam Name	State Regulated	Hazard Class	Emergency Action Plan
Washington	MO30720	Something Green A Dam	False	1	Not Required
Washington	MO30719	Something Green B Dam	False	1	Yes
Washington	MO30698	Spring Glen Lake Dam	False	2	Not Required
Washington	MO30725	Spring Lake Dam	False	1	Not Required
Washington	MO31838	Spring Lake Dam	True	2	Not Required
Washington	MO30710	Sun Mine Dam	True	2	Not Required
Washington	MO30111	Sunnen Dam	True	2	Yes
Washington	MO30996	The Place Lake Dam	False	1	Not Required
Wayne	MO30563	A O Shearrer Lake Dam	False	1	Not Required
Wayne	MO30312	Collins Lake Dam-Sect 16	False	2	Not Required
Wayne	MO31084	Collins Lake Dam-Sect 31	False	2	Not Required
Wayne	MO30007	Eagle Sky Lake Dam	True	2	Not Required
Wayne	MO31602	Lake Janna Dam	False	1	Not Required
Wayne	MO30018	Lake Jeano Dam	False	1	Not Required
Wayne	MO31101	Lake Julia Dam	False	1	Yes
Wayne	MO31944	Lake Lynn Dam	True	1	Yes
Wayne	MO31109	Lake Of The Pines Dam	False	1	Not Required
Wayne	MO30565	Lake Potashnik Dam	False	1	Not Required
Wayne	MO32033	Lake Ray Dam	True	2	No
Wayne	MO30309	Lottes Dam	False	1	Not Required
Wayne	MO30024	Maddox Lake Dam	False	1	Not Required
Wayne	MO30044	Mountain Lake Dam	False	1	Not Required
Wayne	MO30310	Porter Dam	False	2	Not Required
Wayne	MO31420	Rothwell Ranch Lake Dam	False	2	No
Wayne	MO30347	Seven Lakes #1 Dam	True	1	Not Required
Wayne	MO30348	Seven Lakes #2	False	1	Not Required
Wayne	MO31032	Seven Lakes Dam #3	True	1	Not Required
Wayne	MO30043	Sunrise Lake Dam	False	1	Not Required

County	Dam ID	Dam Name	State Regulated	Hazard Class	Emergency Action Plan
Wayne	MO31108	Turner's Dream Lake Dam	False	1	Not Required
Wayne	MO31083	Williams Lake Sec-31 Dam	False	2	Yes
Webster	MO20399	Biggs Lower Lake Dam	False	2	Not Required
Webster	MO30961	Burk Bridge Company East Lake Dam	False	2	No
Webster	MO30962	Burk Bridge Company West Lake Dam	False	2	Not Required
Webster	MO20454	Elk Lake Dam	False	2	Yes
Webster	MO31630	Farthing East Dam	False	2	Not Required
Webster	MO30948	Great Bear Lake Dam	True	2	No
Webster	MO30120	Lake Osage Dam	True	2	Yes
Webster	MO20455	Lake Ralph Foster Dam	False	2	Not Required
Webster	MO20417	Lost Lake Dam	True	2	No
Webster	MO20398	Totten,F A Lake Dam	False	1	No
Worth	MO10067	Dunfee Lake Dam	False	2	Not Required
Worth	MO11054	Platte River Tributaries Dam 3-B	False	1	Not Required
Worth	MO11272	Zollman Lake Dam	False	2	Not Required
Wright	MO31355	D & R Laker Lower Dam	False	2	Not Required
Wright	MO30178	D+R Lake Upper Dam	False	2	Not Required
Wright	MO32056	Freebird Dam	True	2	Not Required
Wright	MO31627	Lehar Lake Dam	False	2	Not Required
Wright	MO31628	Sparlin Lake Dam-Sec 35	False	2	Not Required

Hazus Flood Loss Estimation Annex

During the Region's recent review and approval of the Missouri State Hazard Mitigation Plan, FEMA's planners had raised concern over some of the flooding loss estimations that were produced utilizing FEMA's Hazus software. At that time, SEMA agreed to re-review all of the county flood estimations within a period of 30 days. This letter is the promised Plan Annex, a follow-up to report on the results of SEMA's re-review of that analysis.

SEMA's contractor for the 2013 Plan update, Michael Baker, Jr. (Baker), has now had the opportunity to assess the flood loss estimations that were produced by Hazus and reported in the 2013 Plan. As a summary, Baker conducted Level 2 Hazus Flood runs for all of Missouri's 114 counties, plus the City of St. Louis. The analysis is considered Level 2 because Baker was able to leverage all digital FIRMs available in the State, in addition to the numerous LiDAR data sets available, to greatly improve the accuracy of the loss estimations

The main issue that Baker focused its review on were the seemingly conflicting loss estimations ($) and associated counts of buildings damaged or at risk. It was noted that in a handful of counties, the loss estimations (i.e. - structural damage, contents damage, etc) presented millions of dollars of losses, but yet reported zero buildings at risk or being damaged.

For all counties, Baker initially checked to ensure the data that was incorporated into the Plan matched what was stored in and outputted by Hazus. This review confirmed that the Plan data matched the existing Hazus runs performed earlier in the Plan update process. Baker then re-ran the Hazus analysis from scratch for three of the counties whose loss estimations raised concern. All resulting new loss estimations matched the values previously produced. This analysis confirmed that the results being reported by Hazus are consistent and were not a software bug or glitch.

As mention previously to the Region, Baker also discussed this subject with some of FEMA's top Hazus experts, located in Region VIII. The seemingly conflicting loss estimates were a subject that Region VIII and many other Hazus users across the country are quite familiar with. The explanation is due to how the Hazus flood module attempts to calculate the various loss estimations. Hazus uses census block data as the main building inventory inputs into the software. When estimating potential losses based on a particular flood event, Hazus assumes that the building inventory for each census block is equally weighted across that block. This seems to produce reasonable loss estimations in most instances, except when the flooding only impacts a small percent of a census block. In those cases, it is known that Hazus does introduce conservative losses.

There is currently no other way to reassess these loss estimations. Hazus does allow a user to utilize building specific point data ('site specific'), but at the present time all structures across the State are not mapped to this precision yet. In the future, SEMA will revisit available data sets prior to proceeding with any future Hazus analysis. As was discussed at the 2013 Hazus Users Conference, recently held August 5th-7th, FEMA and its developers are researching alternative ways to more accurately locate the census building stock. These improvements are planned for a future Hazus release. SEMA will continue to monitor this situation and plans to reassess the flood loss estimations at that time.

At this point, SEMA believes the flood loss estimates reported in the 2013 Plan are indeed the best available information. With the goal of making the State Plan a source of consistent and reliable

information for local plan developers, the counts of buildings at risk or being damaged by flood were not included in those Plan tables that detail the Hazus results. SEMA will continue to look to improve, as data and technology allows, all Plan risk assessments during future updates.

Users of the Hazus runs and those associated tables included in this Plan need to be aware that the data is just one source of damage and loss estimation information that can be used in Mitigation Plans. There are other sources of data available, including local building data and/or local monetary loss figures.